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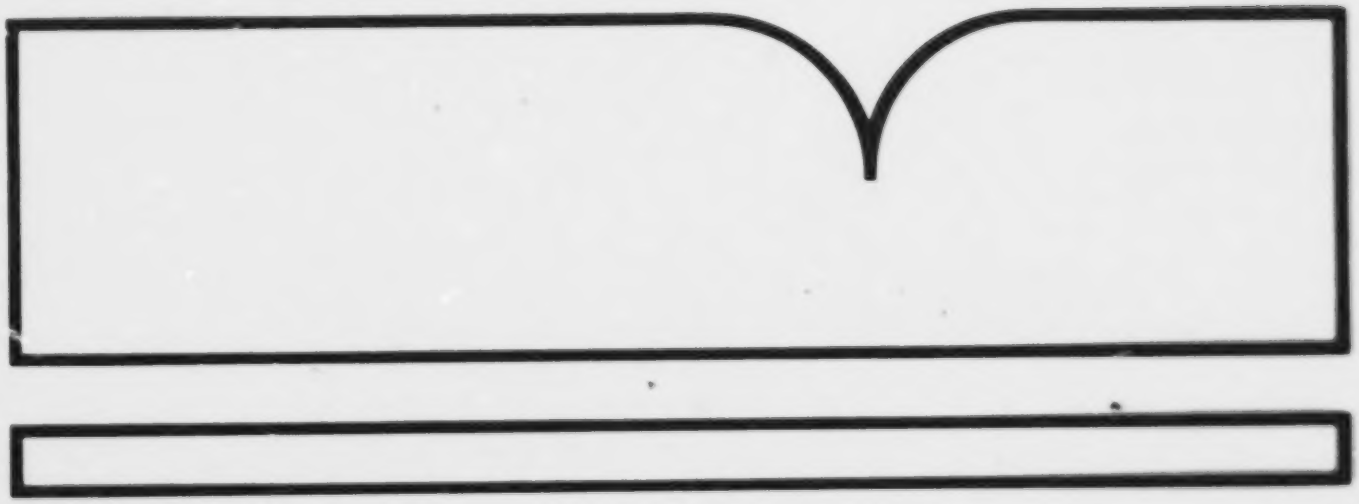
Superfund Innovative Technology Evaluation (SITE) Program Technology Profiles

PEER Consultants, Dayton, OH

Prepared for

Environmental Protection Agency, Cincinnati, OH

Nov 88



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Washington DC 20460

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Development
Washington DC 20460

Superfund

EPA/540/5-88/003 Nov. 1988

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The Superfund Innovative Technology Evaluation Program:

Technology Profiles

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The purpose of this document is to provide Regional decision makers and other interested individuals with a ready reference on those technologies in the SITE Demonstration and Emerging Technologies Programs. Each profile contains a: (1) technology description, (2) discussion on waste applicability, (3) status report, and (4) EPA Project Manager and Technology Contact. Technologies are presented in alphabetical order by developer name with separate sections for the SITE Demonstration and Emerging Technologies Programs.

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THE SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION PROGRAM:

TECHNOLOGY PROFILES

68-03-3490
Work Assignment No. 3

Work Assignment Manager

Jonathan G. Herrmann
Superfund Technology Demonstration Division
Risk Reduction Engineering Laboratory
Cincinnati, Ohio 45268

RISK REDUCTION ENGINEERING LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

DISCLAIMER

The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under Contract No. 68-03-3490, Work Assignment No. 3 to PEER Consultants, P.C. It has been subject to the Agency's administrative and peer review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

Today's rapidly developing and changing technologies, and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Risk Reduction Engineering Laboratory is responsible for planning, implementing, and managing research, development, and demonstration programs to provide an authoritative, defensible engineering basis in support of the policies, programs, and regulations of the EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

This document contains information on technologies being evaluated under the U.S. Environmental Protection Agency's Superfund Innovative Technology Evaluation (SITE) Program. It describes, using the vehicle of Technology Profiles, the technologies in both the SITE Demonstration and Emerging Technologies Programs. The intended audience for this document is Regional decision makers and other interested individuals involved in Superfund site cleanups.

E. Timothy Oppelt, Acting Director
Risk Reduction Engineering Laboratory

ABSTRACT

The purpose of this document is to provide Regional decision makers and other interested individuals with a ready reference on those technologies in the SITE Demonstration and Emerging Technologies Programs. Each profile contains a: (1) technology description, (2) discussion on waste applicability, (3) status report, and (4) EPA Project Manager and Technology Contact. Technologies are presented in alphabetical order by developer name with separate sections for the Demonstration and Emerging Technologies Programs.

This document was submitted in partial fulfillment of Contract No. 68-03-3490, Work Assignment No. 3 by PEER Consultants, P.C., under the sponsorship of the U.S. Environmental Protection Agency. The work necessary for preparing this document was carried out from August 1988 through November 1988.

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This document was prepared in partial fulfillment of Contract No. 68-03-3490, Work Assignment No. 3 by PEER Consultants, P.C., under the sponsorship of the U.S. Environmental Protection Agency. Jonathan G. Herrmann of the Risk Reduction Engineering Laboratory, Cincinnati, Ohio was the Work Assignment Manager responsible for the preparation of this document, assisting him in this effort was Diana Guzman. Special acknowledgement is given to Ronald D. Hill, Director of the Superfund Technology Demonstration Division, Robert A. Olexsey, Chief of the SITE Demonstration and Evaluation Branch, Stephen C. James, Chief of the Demonstration Section and the many EPA Project Managers who provided guidance and technical input. Participating in the development of this document for PEER Consultants, P.C. were Robert Mentzer, Vyvyan Boykin and Barbara Cormier. Special acknowledgement is given to Rebecca Keiter, Helen Owens, Nancy Thomas, Andrew Weisman, Toni Greene and Tammy Hanser for their contributions in the layout and graphics.

EPA United States Environmental Protection Agency

November 1988

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

Program Description

INTRODUCTION:

The Superfund Amendments and Reauthorization Act of 1986 (SARA) (Section 209(b)) amends Title III of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) by adding Section 311 which directs the Environmental Protection Agency to establish an "Alternative or Innovative Treatment Technology Research and Demonstration Program". This program, called the Superfund Innovative Technology Evaluation (SITE) Program, is intended to: (1) accelerate the development, demonstration and use of new or innovative technologies and (2) demonstrate and evaluate new, innovative measurement and monitoring technologies. The overall goal of the SITE Program is to maximize the use of alternatives to land disposal in cleaning up Superfund sites. In essence, alternative technologies are any technologies that are alternatives to current procedures or practices (See Figure 1).

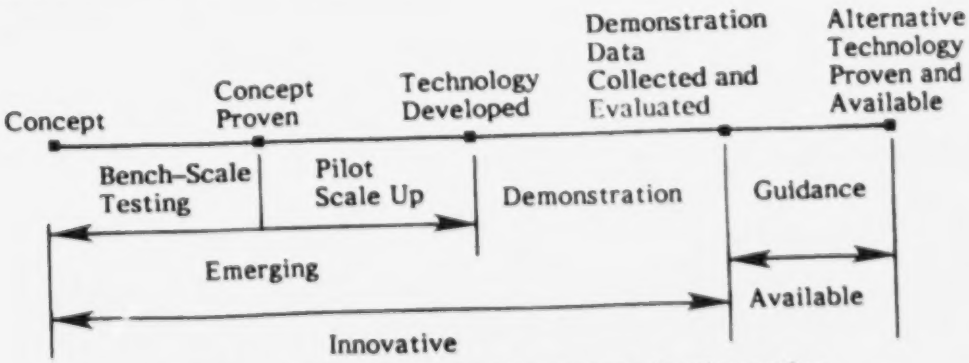

Figure 1. Commercialization process for alternative technologies.

For the SITE Program, alternative technologies are categorized by their commercialization status as follows:

1. **Available Alternative Technology.** A technology that is fully proven and in routine commercial or private use.

2. **Innovative Alternative Technology.** Any fully developed technology for which performance or cost information is incomplete, thus hindering routine use at Superfund sites. An innovative alternative technology requires field testing before it is considered proven and available for routine use.

3. **Emerging Alternative Technology.** An alternative technology at a stage where laboratory testing has been completed and pilot-scale work is now necessary.

To foster this comprehensive program for the commercialization of new and improved technologies, the SITE Program includes the following components:

Demonstration Program — The demonstration and evaluation of technologies on a field-scale. As part of Cooperative Agreements between technology developers and EPA, the developers provide and operate the technology, and the EPA conducts sampling and analysis activities. Demonstrations normally take place at a Superfund site, EPA Test and Evaluation Facility, or the developer's site.

Emerging Technologies Program — The testing and evaluation of technologies from bench-scale through pilot-scale. As part of Cooperative Agreements between technology developers and EPA, the developers refine and improve the technology and the EPA cost shares in the testing and evaluation efforts. Testing normally takes place at the developer's site or an EPA Test and Evaluation Facility.

PROGRAM ACTIVITIES AND CONTACTS:

Requests for Proposals for the Demonstration Program are usually issued in January of every year, and Requests for Preproposals for the Emerging Technologies Program are usually issued in July of each year.

Persons seeking further information on the SITE Program should contact:

SITE PROGRAM
Robert A. Olexsey, Chief
SITE Demonstration and Evaluation Branch
U.S. EPA
26 West Martin Luther King Drive
Cincinnati, OH 45268
513 - 569-7696
FTS: 684-7696

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

DEMONSTRATION PROGRAM

Stephen C. James, Chief
Demonstration Section
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513 - 569-7877
FTS: 684-7877

EMERGING TECHNOLOGIES PROGRAM

Donald E. Sanning, Chief
Emerging Technology Section
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513 - 569-7879
FTS: 684-7879

For SITE information on a specific technology evaluation in either the Demonstration or Emerging Technologies Programs, individuals should direct inquires to the EPA Project Manager for the technology of interest. For information on the technology itself, individuals should direct inquiries to the Technology Contact.

DOCUMENT PURPOSE AND FORMAT

The purpose of this document is to provide Regional decision makers and other interested individuals with a ready reference on those technologies in the SITE Demonstration and Emerging Technologies Programs. Each profile contains a: (1) technology description, (2) discussion on waste applicability, (3) status report, and (4) EPA Project Manager and Technology Contact. Technologies are presented in alphabetical order by developer name with separate sections for the Demonstration and Emerging Technologies Programs.

EPA United States
Environmental Protection
Agency

November 1988

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

Demonstration Program

The objective of the SITE Demonstration Program is to develop reliable performance and cost information on innovative alternative technologies so that they can be adequately considered in the Superfund decision making process. The demonstrations are designed to provide sufficient information to enable potential users to make sound judgements as to the applicability of the technology for a specific site and to compare the technology's effectiveness and costs to other alternatives. The results of the demonstrations identify the limitations of the technology, the potential need for pre- and post-processing of the wastes, the types of wastes and media to which the process can be applied, the potential operating problems, and the approximate capital and operating costs. The demonstrations also permit evaluation of long-term operating and maintenance costs and long-term risks. Demonstrations take place at Superfund sites or under conditions that duplicate or closely simulate actual wastes and conditions found at Superfund sites to assure the reliability of the information collected and acceptability of the data by users. The SITE Demonstration Program participants are presented in alphabetical order in Table 1.

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SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

TABLE 1. SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
American Combustion Technologies, Inc. Norcross, GA (001 - 1986)	Pyretron™ Oxygen Burner	Mark Zwecker 404-662-8156	Laurel Staley 513-569-7881 FTS: 684-7881	Solid	NA	X
Biotrol, Inc. Chaska, MN (003 - 1988)	Biotreatment of Groundwater	Thomas Chresand 612-448-2515	Mary K. Stinson 201-321-6683 FTS: 340-6683	Liquid	Can be applied to nitrates	X
Biotrol, Inc. Chaska, MN (003 - 1988)	Soils Washing	Steve Valine 612-448-2515	Mary K. Stinson 201-321-6683 FTS: 340-6683	Solid	Specific for metals	Specific for high molecular weight organics
CBI Freeze Technologies, Inc. Plainfield, IL (003 - 1988)	Freezing	Matt Husain 815-436-2912	S. Jackson Hubbard 513-569-7507 FTS: 684-7507	Liquid	X	X
CF Systems Corp. Waltham, MA (002 - 1987)	Solvent Extraction	John M. Moses 617-890-1200	Richard Valentinetti 202-382-5753 FTS: 382-5753	Liquid/ Solid	NA	X
Chemfix Technologies, Inc. Metairie, LA (002 - 1987)	Chemical Fixation/ Stabilization	C. Paul Lo 504-831-3600	Edwin Barth 513-569-7669 FTS: 684-7669	Liquid/ Solid	Specific for heavy metals	Specific for high molecular weight organics
DETOX, Inc. Dayton, OH (003 - 1988)	Submerged Aerobic Fixed-Film Reactor	George J. Skladany 513-433-7394	Ronald F. Lewis 513-569-7856 FTS: 684-7856	Liquid	NA	X

X = Applicable NA = Non Applicable

(continued)

TABLE 1. (continued)

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Detox Industries, Inc. Sugarland, TX (001 - 1986)	Biological Degradation	Thomas Dardas 714-240-0892	Ronald F. Lewis 513-569-7856 FTS: 684-7856	Solid	NA	Specific for PCPs and PAHs
E.I. DuPont de Nemours and Company Newark, DE (003 - 1988)	Membrane Microfiltration	Ernest Mayer 302-366-3652	John F. Martin 513-569-7758 FTS: 684-7758	Liquid	X	X
Freeze Technologies Corp. Raleigh, NC (003 - 1988)	Freezing	James A. Heist 919-850-0600	Jonathan G. Herrmann 513-569-7839 FTS: 684-7839	Liquid	X	X
GeoSafe Corp. Kirkland, WA (002 - 1987)	In-Situ Vitrification	James E. Hansen 206-822-4000	Jonathan G. Herrmann 513-569-7839 FTS: 684-7839	Liquid/ Solid	X	X
HAZCON, Inc. Katy, TX (001 - 1986)	Solidification/ Stabilization	Ray Funderburk 713-934-4500	Paul R. de Percin 513-569-7797 FTS: 684-7797	Solid	Specific for heavy metals	X
Haztech Atlanta, GA (001 - 1986)	Shirco Infrared Thermal Destruction	Mark de Lormier 214-404-7540	Howard O. Wall 513-569-7691 FTS: 684-7691	Solid	NA	X
International Waste Technologies Wichita, KS (001 - 1986)	In-Situ Stabilization	Jeff P. Newton 316-269-2660	Mary K. Stinson 201-321-6683 FTS: 340-6683	Solid	X	X

X = Applicable NA = Non Applicable

(continued)

TABLE 1. (continued)

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
MOTEC, Inc. Mt. Juliet, TN (002 - 1987)	Liquid/Solid Contact Digestion	John Bogart 615-754-9626	Eugene F. Harris 513-569-7862 FTS: 684-7862	Liquid/ Solid	NA	X
Ogden Environmental Services San Diego, CA (001 - 1986)	Circulating Fluidized Bed Combustor	Brian Baxter 619-455-2613	Joseph McSorley 919-541-2920 FTS: 629-2920	Liquid/ Solid	NA	X
Resources Conservation Company Bellevue, WA (001 - 1986)	Solvent Extraction	Paul McGough 206-828-2400	Edward R. Bates 513-569-7774 FTS: 684-7774	Liquid/ Solid	NA	Specific for high molecular weight organics
Retech, Inc. Ukiah, CA (002 - 1987)	Plasma Heat	R.C. Eschenback 707-462-6522	Laurel Staley 513-569-7881 FTS: 684-7881	Liquid/ Solid	NA	X
Sanitech, Inc. Twinsburg, OH (002 - 1987)	Ion Exchange	Sidney G. Nelson 216-425-2354	Richard Traver 201-321-6677 FTS: 340-6677	Liquid	Specific for heavy metals	NA
Separation and Recovery Systems, Inc. Irvine, CA (003 - 1988)	Solidification/ Stabilization	Joseph de Franco 714-261-8860	Richard Valentinetti 202-382-5753 FTS: 382-5753	Liquid/ Solid	X	Specific for acid sludges with at least 3% hydrocarbons
Silicate Technology Corporation Scottsdale, AZ (003 - 1988)	Solidification/ Stabilization Using Silicate Compounds	Steve Pegler 602-948-1300	Edward R. Bates 513-569-7774 FTS: 684-7774	Liquid/ Solid	Specific for heavy metals	Specific for high molecular weight organics

(continued)

X = Applicable NA = Non Applicable

TABLE 1. (continued)

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Soliditech, Inc. Houston, TX (002 - 1987)	Solidification	Carl Brassow 713-778-1800	Walter E. Grube 513-569-7798 FTS: 684-7798	Liquid	X	X
Terra Vac, Inc. San Juan, PR (001 - 1986)	In-Situ Vacuum Extraction	James Malot 809-723-9171	Mary K. Stinson 201-321-6683 FTS: 340-6683	Liquid/ Solid	NA	Specific for highly volatile organics
Toxic Treatments San Mateo, CA (003 - 1988)	In-Situ Steam/ Air Stripping	A.P. Statham 415-572-2994	Paul de Percin 513-569-7797 FTS: 684-7797	Solid	NA	X
Ultrox International Santa Ana, CA (003 - 1988)	Ultraviolet/Oxidation Treatment for Liquids	David B. Fletcher 714-545-5557	Norma Lewis 513-569-7665 FTS: 684-7665	Liquid	NA	X
WasteChem Corp. Paramus, NJ (002 - 1987)	Volume Reduction/ Solidification	Hans Theyer 201-599-2900	S. Jackson Hubbard 513-569-7507 FTS: 684-7507	Liquid/ Solid	NA	X
Westinghouse Electric Corp. Madison, PA (001 - 1986)	Pyroplasma System	John F. Gross 412-722-5655	Eugene F. Harris 513-569-7862 FTS: 684-7862	Liquid	NA	Specific for chlorinated and high molecular weight organics
Zimpro/ Passavant, Inc. Rothschild, WI (002 - 1987)	Powdered Activated Carbon/Biological	William M. Copa 715-359-7211	John F. Martin 513-569-7758 FTS: 684-7758	Liquid	NA	X

X = Applicable NA = Non Applicable

EPA Technology Profile
Demonstration Program
SITE SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION
November 1988

AMERICAN COMBUSTION TECHNOLOGIES, INC.

TECHNOLOGY DESCRIPTION:
The PYRETRON, an oxygen-air-fuel burner, uses advanced fuel injection and mixing concepts to provide faster ignition and more thorough burning of wastes. Burner operation is computer controlled to automatically adjust the amount of oxygen according to sudden changes in the heating value of the waste. The burner can be fitted onto any conventional combustion unit for burning liquids, solids and sludges.

Pure oxygen in combination with air and natural gas is burned in the PYRETRON burner to destroy solid hazardous waste (Figure 1). Solids and sludges can be co-incinerated when the burner is used in conjunction with a rotary kiln or similar equipment. The use of oxygen allows a higher burning temperature (up to 4500°F as compared to a maximum of 2400°F in a conventional burner) without the addition of excess air. Using less air is advantageous because the nitrogen in air takes away heat, puts a greater load on the air pollution control equipment, and requires a longer retention time in the combustor before the waste is fully incinerated. The higher temperatures also ensure more complete incineration of the wastes, thereby increasing the destruction and removal efficiency and reducing stack gas emissions. The rate of waste throughput is also increased, thus reducing unit costs.

WASTE APPLICABILITY: Solid wastes contaminated with hazardous organics are suitable for the PYRETRON. Generally, the technology is applicable to any waste that can be incinerated. However, no advantages are known in processing aqueous wastes, RCRA heavy metal wastes, or non-organic wastes.

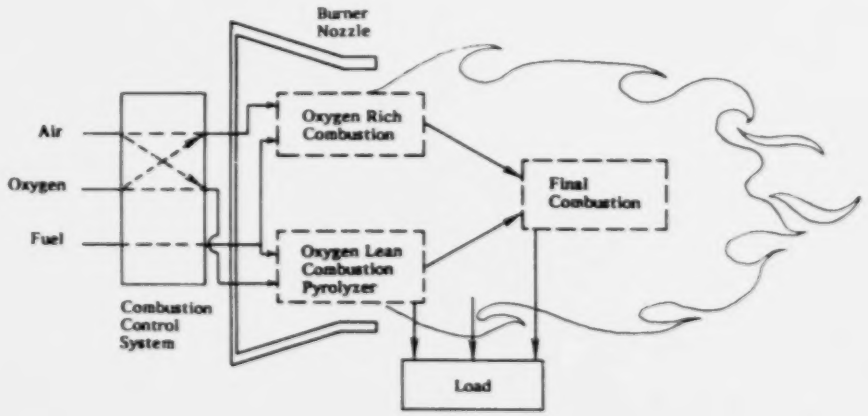

Figure 1. Pyretron combustion and heating process flow diagram.

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STATUS: The demonstration project, using contaminated soil from the Stringfellow Acid Pit Superfund site in California and decanter tank tar sludge, began in November 1987; it was completed at the end of January 1988. The demonstration was conducted at EPA's Combustion Research Facility in Jefferson, Arkansas.

Recently, the draft demonstration report was received and distributed for review by EPA. The applications analysis report is also being prepared. The final report is expected to be released by December 1988.

FOR FURTHER INFORMATION:

EPA Project Manager:
Laurel Staley
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7881
FTS: 684-7881

Technology Contact:
Mark Zwecker
American Combustion Technologies, Inc.
2985 Gateway Drive, Suite 100
Norcross, Georgia 30071
404-662-8156

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

BIOTROL, INC.

TECHNOLOGY DESCRIPTION: The Aqueous Treatment System (ATS) is a remediation approach based on the use of specific microorganisms as the sole treatment agent for the biodegradation of toxic organic compounds in groundwater. Both broad spectrum removal as well as toxics removal of organics can be accomplished by use of specific microbes. The microbiological system selected completely degrades the organic contaminants via immobilized film bioreactor units without leaving residual intermediate compounds. Depending upon the target contaminants, these units can be based on either aerobic or anaerobic conditions.

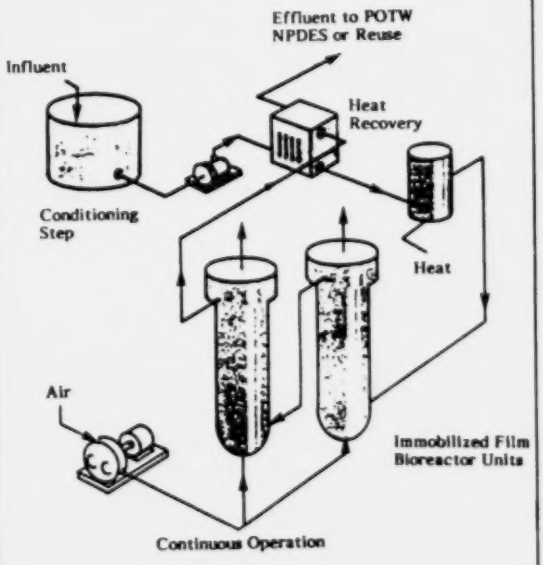

Figure 1. Biotrol aqueous treatment system process diagram.

The ATS consists of a receiving tank, a heating unit, two bioreactor units, and an air supply unit. In essence, contaminated influent enters a receiving tank where it is conditioned for treatment (Figure 1). After treatment, the water passes through a heating unit; heat conservation is used to control the temperature of influent water and to minimize energy requirements. Then, the water enters the center of the ATS, the submerged packed bed bioreactors, where the microbes are immobilized as a fixed film, and the packed bed is submerged in the water stream. Aeration is accomplished by spraying a stream of bubbles through the bed, and therefore, a long residence time is realized in the bioreactor units. As the water is passed through the bioreactor units, the microbes mineralize and/or metabolize the organic contaminants into harmless constituents, including carbon dioxide and water. Finally, the decontamination effluent flows out of the bioreactor units to a POTW or for reuse. It is also monitored to assure system performance is at the required discharge standards.

According to the developer, this technology will require expertise in the isolation and cultivation of unique microbes, and the amendment of indigenous microbial populations. It will also require the design of wastewater treatment systems and the design of low-cost bioreactors.

WASTE APPLICABILITY: This technology is mainly applicable to groundwaters contaminated with organic compounds, such as pentachlorophenol and creosote from wood-treating chemicals, gasoline or other fuels' hydrocarbons, pesticides, halogenated aliphatic solvents (such as trichloroethylene and many others), alcohols, phenolic and PNA wastes from coal gasification processes, and effluent

from pulp and paper mills. This technology is also applicable for the removal of certain inorganic compounds (such as nitrates); however, it cannot be applied to metals removal.

Other potential wastestreams that are targeted for treatment in the ATS include chlorinated hydrocarbons, coal tar residues, and organic pesticides. Underground storage tank contaminants, such as fuels and solvents, are also being evaluated.

STATUS: A wood-preserving facility, possibly in the state of Washington, will most likely be considered for the demonstration project under the Superfund Innovative Technology Evaluation (SITE) Program.

FOR FURTHER INFORMATION:

EPA Project Manager:
Mary K. Stinson
U.S. EPA
Risk Reduction Engineering Laboratory
Woodbridge Avenue
Edison, New Jersey 08837
201-321-6683
FTS: 340-6683

Technology Contact:
Thomas Chresand
Biotrol, Inc.
11 Peavey Road
Chaska, Minnesota 55318
612-448-2515

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

BIOTROL, INC.

TECHNOLOGY DESCRIPTION: The Soils Treatment System (STS) is a remediation strategy based on a series of physical separation and washing steps using water as a carrier for the soil. The objective of the system is to reduce significantly the level of contaminants in soils, to recover the contaminants for reuse or disposal (effecting a volume reduction), and to achieve the environmental remediation standards required of the contaminated site. This technology is most effective on soils with a high proportion of sand having a majority of the soil particles coarser than 200 mesh. The fine silts and clays typically adsorb and/or absorb organic contaminants disproportionately due to surface chemistry phenomenon and high surface areas. The STS removes these fine particles along with oils and solid organic materials as a concentrated contaminated stream to be disposed of by other means and finally, leaves a washed coarse soil as the "cleaned" product.

This soil treatment process begins with the excavation and screening of the contaminated soil to remove oversized material and debris, typically from one-half to 1 inch size (Figure 1). A system to process oversized material could include various segregation methods to sort debris into categories followed by size reduction of certain categories. Each type of debris would be processed by appropriate treatment methods prior to disposal, and the debris handling equipment would have to be engineered on a case-by-case basis.

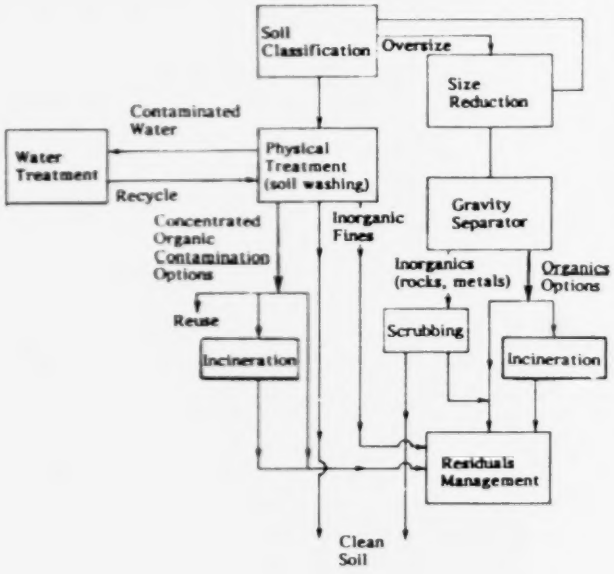

Figure 1. Biotrol soil treatment system process diagram.

Following debris removal, the contaminated soil is then fed to the soil washing system where hydrophobic components (such as oil and certain clay minerals) are removed, and the flotation underflow stream contains the bulk of the soil while the organic contaminants are concentrated in the froth phase. The soil then enters a countercurrent scrubbing system (within the soil washing system) composed of attrition scrubbing and spiral classification of the soil. From here, the contaminated water enters some type of water treatment system (usually a fixed-film reactor) and is recycled back to the soil washing system. It then leaves as concentrated organic contamination for recycling to the process or decontamination. The bulk of the soil from the soil washing process will leave as clean soil, and the inorganic, fine, clay-type particles (which typically are laden with organic contaminants) leaving the process undergo some type of residual management.

WASTE APPLICABILITY: This technology was initially developed for cleaning soils contaminated with oil, pentachlorophenol, and creosote (polyaromatic hydrocarbons) from wood-preserving sites. It is also expected to be applicable to other contaminants such as fuel oils, PCBs, and metals.

STATUS: A demonstration under the Superfund Innovative Technology Evaluation (SITE) Program will occur at a wood-preserving facility. The average soil from such a site is expected to contain 1 to 5 percent total oil, grease and creosote, including up to 5000 ppm of pentachlorophenol. Currently, the site has not been selected.

FOR FURTHER INFORMATION:

EPA Project Manager:
Mary K. Stinson
U.S. EPA
Risk Reduction Engineering Laboratory
Woodbridge Avenue
Edison, New Jersey 08837
201-321-6683
FTS: 340-6683

Technology Contact:
Steve Valine
Biotrol, Inc.
11 Peavey Road
Chaska, Minnesota 55318
612-448-2515

EPA Technology Profile
Demonstration Program
SITE SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION
November 1988

CBI FREEZE TECHNOLOGIES, INC.

TECHNOLOGY DESCRIPTION: Freeze concentration is a physical process based on the well established principle that ice crystals formed by partial freezing of a solution essentially contain only pure water. These ice crystals, when separated from the mother liquor (brine), washed and melted, produce salt free water. The mother liquor retains essentially all foreign elements originally present and becomes concentrated as a result of water removal.

In an indirect freeze process, a refrigerant absorbs heat through a metallic barrier from a flowing solution, cooling the brine to its freezing point. It is most desirable and important that ice crystals form in the bulk of the liquid without growth on the heat removal surface.

The most significant feature of the system is the vertical freeze exchanger, which is basically a shell and tube heat exchanger. The solution flows downward as a falling film inside the exchanger tubes while refrigerant is outside the tubes (shell side of exchanger). Ice sticking to the tubes or ice blockage of the tubes does not occur because of the tube surface preparation and the design of the brine inlet at the top of the freeze exchanger.

A flow schematic of the system is shown in Figure 1. Aqueous waste is fed to the freezer from the feed tank where water is frozen in the form of distinct ice crystals. A slurry of ice crystals, mother liquor and any precipitate which may have formed is sent to the ice separation tank from where a slurry of ice crystals and mother liquor is sent to a gravity wash column. In the wash column, ice crystals rise to the top and form an ice pack which is continuously rinsed and scraped at the top. The harvested ice crystals are then melted recovering the refrigeration to produce the water. A slurry of precipitates

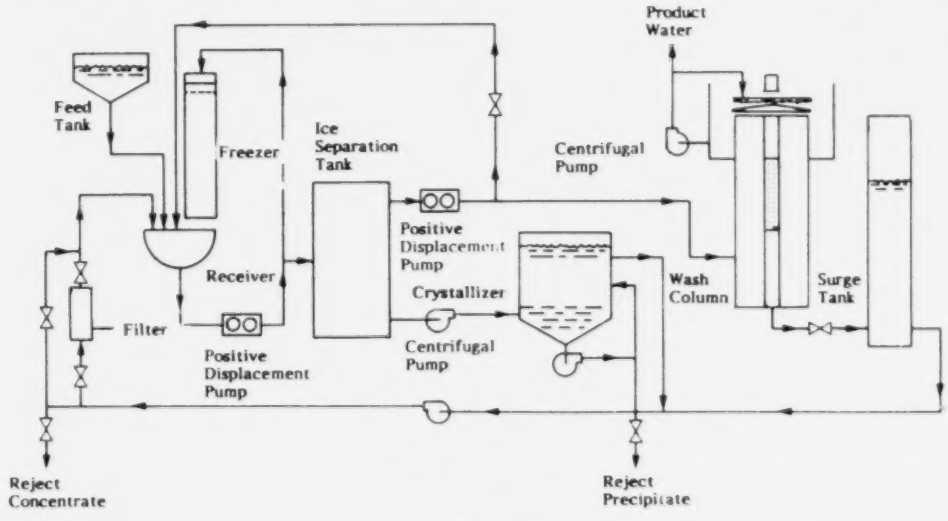

Figure 1. Process flow schematic

and mother liquor from the separation tank is sent to a crystallizer vessel where precipitates are grown, separated from mother liquor and discharged. Most of the concentrated mother liquor from the wash column and crystallizer is recycled back to the freezer, rejecting a measured amount as the final concentrate of the aqueous waste.

WASTE APPLICABILITY: Liquid wastes containing ions, metals, organic compounds and pesticide rinse waters are suitable for this technology. Waste containing from 1 to 10 weight percent dissolved solids can also be treated by this system.

STATUS: The work assignment to develop the Demonstration plan has been submitted to the contracts office. The cooperative agreement application is being prepared prior to submission to the Grants Administration Division (GAD). Currently, site selection is proceeding.

FOR FURTHER INFORMATION:

EPA Project Manager:
S. Jackson Hubbard
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7507
FTS: 684-7507

Technology Contact:
Matt Husain
CBI Freeze Technologies, Inc.
1501 Division Street
Plainfield, Illinois 60544
815-436-2912

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

CF SYSTEMS CORPORATION

TECHNOLOGY DESCRIPTION: This technology utilizes liquified gases as the extracting solvent to remove organics, such as hydrocarbons, oil and grease, from wastewater or contaminated sludges and soils. Carbon dioxide is generally used for aqueous solutions, and propane is used for sediment, sludges and soils (semisolids).

Contaminated sediments are fed into the top of the extractor (Figure 1). Solvent (condensed by compression at 70°F) flows upwards through the extractor, making non-reactive contact with the waste. Typically, 99 percent of the organics are dissolved out by the solvent. Then, clean material is removed from the extractor. A mixture of solvent and organics leave the extractor, passing to the separator through a valve where pressure is partially reduced. In the separator, the solvent is vaporized and recycled as fresh solvent. Finally, the organics are drawn off from the separator, recovered for disposal, or reused off-site in industrial processes.

The difference in the mobile units for aqueous solutions and semisolids can be found in the extractor. For example, mixing variations can exist in the extractor whereby aqueous solutions can go through one type of mixer having a series of trays while semisolids can go through a "cement-type" mixer.

WASTE APPLICABILITY: This technology can be applied to a wide variety of organics such as the following: carbon tetrachloride, chloroform, benzene, naphthalene, gasoline, vinyl acetate, furfural, butyric acid, higher organic acids, dichloroethane, oils and grease, xylene, toluene, methyl acetate, acetone, higher alcohols, butanol, propanol, phenol, heptane, PCBs and other complex organics.

STATUS: Currently, a pilot-scale system has been tested on PCB-laden harbor sediments from the Massachusetts New Bedford Harbor Superfund site during September 1988. During

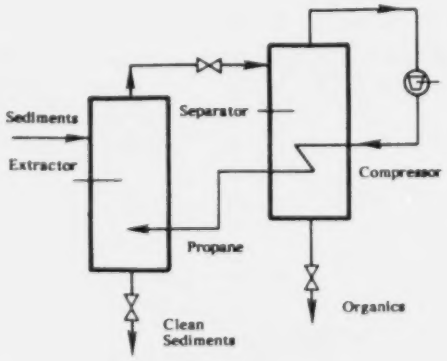

Figure 1. Solvent extraction unit process diagram.

the test, PCB concentrations (ranging from 300 ppm to 5000 ppm) and the number of passes through the unit were varied for each of the four separate test runs. About one-half drum (30 gallons) of sediments, with additional water added to obtain the appropriate consistency, was processed for each run. Results of the demonstration will be available in several months.

FOR FURTHER INFORMATION:

EPA Project Manager:
Richard Valentinetti
U.S. EPA (RD-681)
401 M Street, SW
Washington, D.C. 20460
202-382-5753
FTS: 382-5753

Technology Contact:
John M. Moses
CF Systems Corporation
140 Second Avenue
Waltham, Massachusetts 02154
617-890-1200

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

CHEMFIX TECHNOLOGIES, INC.

TECHNOLOGY DESCRIPTION:
This chemical fixation/stabilization process is based on the use of soluble silicates and silicate setting agents. The inorganic chemical system reacts with polyvalent metal ions, certain other waste components, and also with itself to produce a chemically and physically stable solid material. The cross-linked, three dimensional polymeric matrix displays properties of good stability, high melting point, and a rigid, friable texture similar to that of a soil.

Within this process (Figure 1), a liquid or solid waste is first blended in the reaction vessel with certain reagents, which are dispersed and become dissolved throughout the aqueous phase. Reactions occur using the reagents, polyvalent cations in the waste, and some of the water. Inorganic polymer chains (insoluble metal silicates) form throughout the aqueous phase and physically entrap the organic colloids within the microstructure of the product matrix. Then, the water soluble silicates are reacted with complex cations in the presence of a siliceous setting agent, producing amorphous, colloidal silicates (a gel structure) and SiO_2 which acts as a precipitating agent. Most of the heavy metals contained in the waste become part of the complex silicates with some of the heavy metals precipitating with the structure of the complex molecules. However, a very small percentage (estimated to be less than one percent) of the heavy metals precipitate between the complex silicates and are not chemically immobilized.

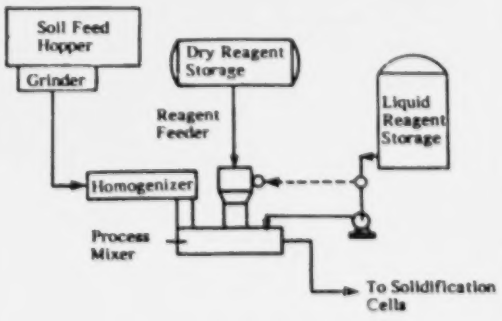

Figure 1. Soil treatment system.

Since some organics may be larger particles than the colloids, all of the waste (during the process treatment) is pumped through processing equipment, creating sufficient shear to emulsify such organic constituents. Emulsified organics are then solidified. This mixture is then discharged to a prepared solidification area in which the gel continues to set. Cementitious reactions create a solid which, though friable, encases within its macrostructure organic substances which may have escaped emulsification. Such substances are immobilized by the impermeability of the macrostructure. Portions of the water contained in the wastes are involved in three reactions after treatment: (1) hydration similar to that of cement reactions; (2) hydrolysis reactions; and (3) equilibration with the environment through evaporation. There are no side streams or discharges from this process. However, the gel which was formed during processing is discharged to a receiving area. Even at this stage, the water in the product does not form a separate phase; some of the water becomes part of the solids, but most is physically bound in the hydrophilic product. Although it can evaporate, it is not free water.

WASTE APPLICABILITY: This technology is suitable for base, neutral, or acid extractable organics of high molecular weight such as refinery wastes, creosote, and wood-treating wastes.

It is also applicable to heavy metals such as aluminum, antimony, arsenic, barium, beryllium, cadium, chromium, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc.

This technology has also proven successful for fixing heavy metals in wastes such as electroplating wastes, refinery wastes, contaminated soil, electric arc furnace dust and municipal sewerage sludge. With or without additives, this process has been noted to be effective for organic constituents with low solubility.

STATUS: Presently, the Demonstration Plan is scheduled for completion in November 1988. The demonstration project is scheduled to begin in early 1989.

FOR FURTHER INFORMATION:

EPA Project Manager:
Edwin Barth
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7669
FTS: 684-7669

Technology Contact:
C. Paul Lo
Chemfix Technologies, Inc.
Suite 620, Metairie Center
2424 Edenborn Avenue
Metairie, Louisiana 70001
504-831-3600

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

DETOX, INC.

TECHNOLOGY DESCRIPTION: This submerged fixed-film bioreactor system relies on aerobic microbial processes to metabolize contaminants present in a liquid waste stream. The unique design of this system allows it to biologically treat liquids containing low concentrations (<20 ppm) of readily biodegradable materials and discharge concentrations in the low parts per billion (ppb) range. The bioreactor can also operate at hydraulic retention times as low as one hour.

The biological treatment system consists of an above ground fixed-film reactor, supplemental nutrient storage tank and pump, sump tank with pump, cartridge filter, and final activated-carbon filter. The bioreactor is operated on a one-pass, continuous-flow basis. The process begins (Figure 1) when water from a groundwater well or equalization tank is pumped directly into the bioreactor. The influent stream is evenly dispersed over the reactor packing through the use of a header-distribution system. High surface area plastic media is used to fill the reactor, and the water level within the reactor is set to cover all of the packing material. Bacterial growth is attached as film to the surface of the plastic media.

As water passes by the biofilm, organics are removed. An air distribution system below the plastic media supplies oxygen to the bacteria in the form of fine bubbles. An effluent water header system collects water from the bottom of the reactor after it has been treated. Water exiting the reactor is passed through a cartridge filter to remove biological solids, and is finally passed through an activated-carbon canister to ensure that all organics have been removed (Figure 1). Depending upon the effluent water discharge criteria, the cartridge and carbon filters may not be needed. The water to be treated must also fall within guidelines for pH (6.5 to 8.5) and temperature (60-95°F), and be free of toxic and/or inhibitory compounds which may include certain metals.

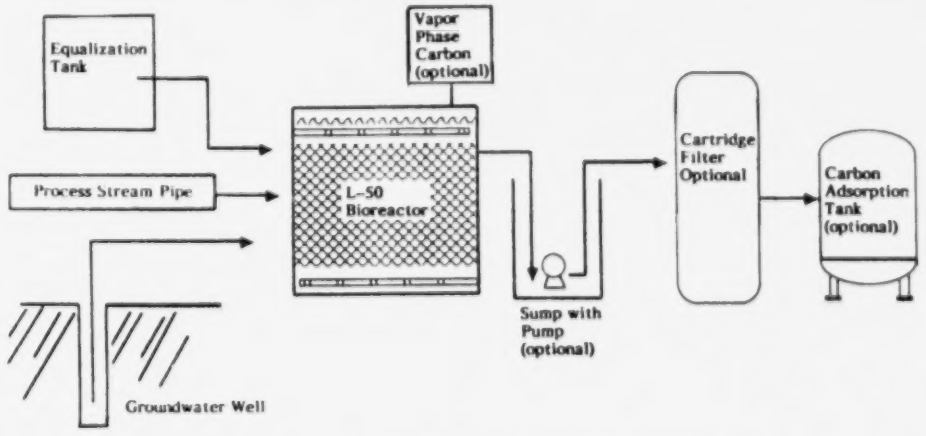

Figure 1. Proposed Detox biological treatment system.

WASTE APPLICABILITY: This technology is typically used to treat groundwater and industrial process waters, but is also applicable to lagoon and/or pond waters. Since the bioreactor uses an aerobic microbial metabolism to destroy contaminants in the waste stream, readily biodegradable compounds such as methyl ethyl ketone (MEK) and benzene can be treated along with some organic chemicals initially more resistant to biodegradation, e.g., chlorobenzene. However, certain halogenated compounds (such as tetrachloroethylene, trichloroethylene and chloroform) are not readily biodegraded by a strictly aerobic process and are not amenable to treatment within these systems.

STATUS: Currently, efforts are underway to find a suitable site for a demonstration project using this technology.

FOR FURTHER INFORMATION:

EPA Project Manager:
Ronald F. Lewis, Ph.D.
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7856
FTS: 684-7856

Technology Contact:
George J. Skladany
DETOX, Inc.
759 East Congress Park Drive
Dayton, Ohio 45459
513-433-7394

DETOX INDUSTRIES, INC.

TECHNOLOGY DESCRIPTION: The essence of this biotechnology involves the adaptation of naturally occurring microorganisms to perform specific biodegradation of targeted organic hazardous wastes. Once these microbes are adapted, the process involves the accelerated growth of these microorganisms and their innoculation into the contaminated soil or the slurry tank in which the waste is contained. Nutrients and catalysts are added to the matrix to enhance the microbial activity. The process involves the slurrying of a contaminated soil with water in an open top agitated tank (Figure 1). The tank has special air inlet distributors to supply air required for metabolism by aerobic bacteria and to keep the soil in suspension. Subsequent innoculations of microorganisms, nutrients and catalysts are added over time when necessary. The result is a systematic biodegradation of the organic contaminants over a relatively short period of time (usually two to four months).

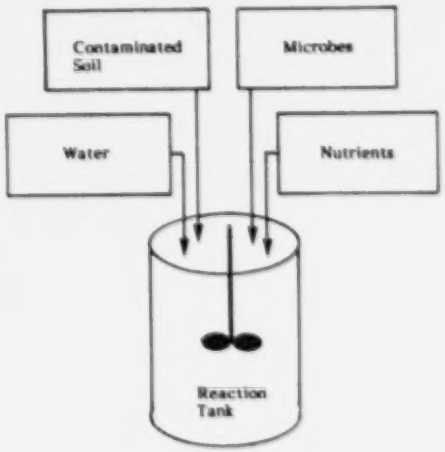

Figure 1. Biodegradation process diagram.

By-products of this metabolic consumption are carbon dioxide, water and cell protoplasm. Once the organic contaminants have been biodegraded, the microbes die out due to the lack of their adapted food source. This leaves nonhazardous cell protoplasm behind which in turn acts as a food source for the indigenous microorganisms present in the matrix.

The treatment period can be from one week to up to four months in the reaction tank to destroy the organic contaminants. Sampling and analyses will show when the treatment is completed, the liquids could be discharged, and the soil could be returned to its point of origin. Biotreatment can occur in the 5 to 40°C range while reaction rates are slower at 5 to 12°C than they are at 18 to 30°C. The liquid effluent may be discharged to a sewer to go to a municipal waste treatment plant. Or, it can be discharged to a surface water (creek, stream or lake) provided it meets NPDES discharge permit requirements and does not contain significant levels of priority pollutants after the treatment process. The solid residue after treatment may be returned to its point of origin for delisting or may be taken to a municipal landfill if it no longer contains priority pollutants. Otherwise, the sludge and soil will need to be treated as a hazardous solid waste and will require incineration or disposal to a secure landfill site.

For full-scale treatment, either much larger reaction tanks can be built or the treatment can be performed in lagoons created on site by using synthetic liners, emplaced in areas from which contaminated soil had been excavated for treatment. Floating aerators can also be used in these lagoons which may contain up to 300,000 gallons of slurry to be treated.

WASTE APPLICABILITY: This technology is suitable for treating liquids, sludges and soils. Currently, microorganisms have been developed to biodegrade the following organic contaminants, which until now were felt to be too refractory in nature to biodegrade: polychlorinated biphenyls (PCBs), pentachlorophenol (PCP), creosote, oil, phenolics, polycyclic aromatic hydrocarbons (PAHs), chlordane and myrex.

STATUS: Pilot tests have been conducted on the degradation of creosote wastes and PCB-laden wastes. However, the process is amenable for the treatment of other types of organic wastes.

The pilot study will use 2 to 5 cubic yards of soil with added water and nutrients making a final volume of approximately 300 cubic feet of slurry in the reaction tank. Biodegradation will continue with monitoring until either no further significant degradation occurs for a period of 2 to 3 weeks or 4 months of treatment has elapsed. The developer and the U.S. EPA wish to test the maximum amount of degradation that can be achieved in a reasonable period of treatment.

Currently, a demonstration project is scheduled to occur at the United Creosote Superfund site in Conroe, Texas. The total site, comprised of about 100 acres, contained two large waste ponds which were used to treat or dispose of the creosote wastes. These ponds are causing a plume of contaminated groundwater. At this time, soil samples for the treatability study have been collected and are being held until the developer is ready to proceed with the bench-scale study.

FOR FURTHER INFORMATION:

EPA Program Manager:
Ronald F. Lewis, Ph.D.
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7856
FTS: 684-7856

Technology Contact:
Thomas Dardas
Detox Industries, Inc.
12919 Dairy-Ashford
Sugarland, Texas 77478
714-240-0892

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

E.I. DUPONT DE NEMOURS AND COMPANY

TECHNOLOGY DESCRIPTION: The automatic pressure filter (APF) system uses low-cost, DuPont Tyvek® roll goods for automatic microfiltration of hazardous wastes in an enclosed, unattended manner. The filter unit, manufactured by the Oberlin Filter Company, produces dry filter cakes (40-60% solids) that are suitable for further treatment (i.e., landfilling, storage, incineration, recycling, etc.). This treatment unit is mobile and is similar to the trailer-mounted dewatering systems (e.g., filter presses, belt presses, centrifuges, etc.) currently used throughout the U.S. for lagoon and basin cleanup operations.

In the APF process (Figure 1), liquid hazardous wastes are pumped into a sealed chamber (platen) through the special sub-micron Tyvek® filter media (which has a throughput 10 times higher than conventional Tyvek®) at a fairly high operating pressure (up to 60 psig). The resulting filter cake and filtrate from this system may require further treatment prior to disposal.

WASTE APPLICABILITY: This combination technology can treat hazardous waste suspensions, particularly heavy metal effluents, groundwater leachate, stilling basin leachate and runoff, oily wastes, radioactive wastes, etc., with solids concentrations ranging between 10 and 300,000 ppm. The APF system is best suited for low solids wastewater (less than 5,000 ppm solids); otherwise, cake capacity and handling becomes limiting. Any type of solids can be handled including inorganics, organics, and oily wastes, with a wide variety of particle sizes. Particulates as small as 0.1 micron may be separated.

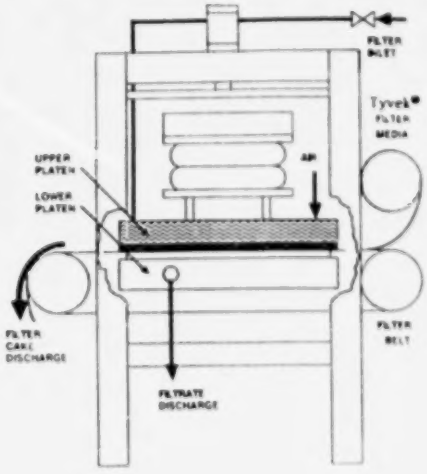

Figure 1. Oberlin APF/Tyvek® process diagram

Volatile wastes can also be processed because the unit is enclosed. For example, the APF system can be used for volatile organic solids removal, prior to deep-well injection. Waste liquids having viscosities as high as 16 cps have also been treated.

STATUS: Activities on this demonstration project have been recently initiated. The site selection process is just getting underway.

FOR FURTHER INFORMATION:

EPA Project Manager:
John F. Martin
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7758
FTS: 684-7758

Technology Contact:
Ernest Mayer, Ph.D.
E.I. DuPont de Nemours and Company
Engineering Department L1359
P.O. Box 6090
Newark, Delaware 19714-6090
302-366-3652

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

FREEZE TECHNOLOGIES CORPORATION

TECHNOLOGY DESCRIPTION: Freeze crystallization operates on the principal that when water freezes, the ice crystal structure that forms naturally excludes all contaminants from the water molecule matrix (Figure 1). Thus, when the ice crystals are recovered and washed with pure water to remove any adhering brine contaminants, that which remains is very pure water.

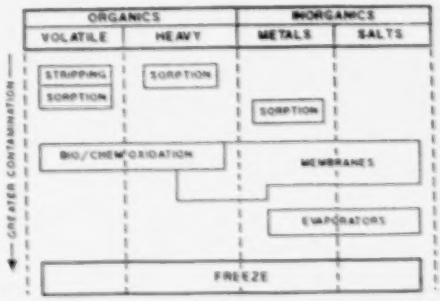

Figure 1. Water molecule matrix.

A version of freeze crystallization that directly injects the refrigerant into the waste has been created by the developer. In this process, the mixed waste liquid enters through the feed heat exchanger where it is cooled to within a few degrees of its freezing temperature (Figure 2). The cooled feed then enters the crystallizer where it is mixed with boiling refrigerant. Water is crystallized in the stirred solution, and is maintained at a uniform concentration or ice fraction by continuous removal of a slurry stream (liquid + ice) that flows to the eutectic separator-growth column. The eutectic separator is used in the system when dissolved materials in the feed are themselves crystallized because of high water recoveries. The growth

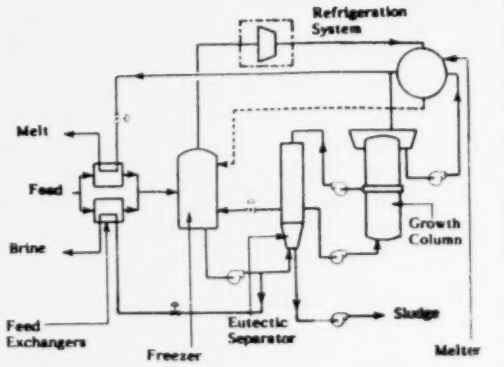

Figure 2. Process schematic.

column is a zone where water crystals are increased in size to better accomodate subsequent washing.

Ice slurry from the crystal separator is pumped to the wash column where it forms a porous pack. The slurry liquid is removed from the column via screened openings, and is then either returned to the eutectic separator or is removed from the system for recycle/disposal. The ice is separated from the liquid in the wash column by filtering screens that allow passage of liquid concentrate but not the ice crystals. Hydraulic forces generated (by the flow of liquid to the screens in the middle of the ice pack) provide the mechanism for propelling the ice pack upward in the column. Ice is washed with melt water and scraped from the top of the pack into a reslurry chamber in the wash column. Within the wash column, melted product is used to transport the ice to a shell and tube heat exchanger, where the slurry is heated on the tube side and hot refrigerant gas is condensed on the shell side.

In most applications, more heat is generated by melting the ice in the refrigeration system than can be used. This leaves some uncondensed refrigeration vapor that needs to be further compressed and condensed by cooling water in a heat reinjection system.

All refrigerants are soluble in water to some degree. Strippers are therefore provided in the system to remove this refrigerant from the purified water, the concentrated liquid, and any other liquid phases produced from the process. The strippers operate under vacuum and contain heaters which generate low pressure steam to enhance refrigerant removal, if that is necessary. Excess generating capacity is built into the melt stripper for use in rapid melt-out of vessels and lines for maintenance or other access.

WASTE APPLICABILITY: This technology will remove both organic and inorganic, ionic and non-ionic species, from contaminated aqueous streams. It works on both surface waters and groundwaters as well as directly on process wastes.

The process is applicable to free liquids, whether the solvent is water or an organic. It can also be used in conjunction with other processes to treat other media. For example, contaminated soils can be washed to transfer the contaminant into a liquid (i.e., water) medium. This has not been particularly attractive because of the low concentrations in the washing medium. Freezing can concentrate this to allow by-product recovery or more economical final destruction.

STATUS: This project was accepted into the SITE Demonstration Program in July 1988. Activities associated with the evaluation of the technology were initiated in August 1988, with site selection currently the focus of activity.

FOR FURTHER INFORMATION:

EPA Contact:
Jonathan G. Herrmann
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7839
FTS: 684-7839

Technology Contact:
James A. Heist
Freeze Technologies Corporation
2539-C Timberlake Road
P.O. Box 40968
Raleigh, North Carolina 27629-0968
919-850-0600

EPA Technology Profile
Demonstration Program
SITE SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION
November 1988

GEOSAFE CORPORATION

TECHNOLOGY DESCRIPTION: In-Situ Vitrification (ISV) is based on the concept of joule-heating to electrically melt soil or sludge. Melt temperatures, in the range of 1600 to 2000°C, act to destroy organic pollutants by pyrolysis. Inorganic pollutants are immobilized within the vitrified mass. Both the airborne organic and inorganic combustion by-products are collected in a negatively pressurized hood which draws the contaminants into an off-gas treatment system that removes particulates and other pollutants of concern.

The ISV technology is trailer-mounted on three semitrailers that are suitable for highway transport. At the site to be treated, the system must be set up on relatively level ground for most effective operation. The vitrification process (Figure 1) is carried out by inserting large electrodes into contaminated zones containing sufficient soil to support formation of a melt. Graphite is placed on the surface to complete the circuit between the electrodes. An electric current is passed through the electrodes and graphite, and the heat generated from this current causes a melt that gradually works downward through the soil. This process permits soil or sludge to be vitrified over an area of approximately 27 feet on a side to a depth of 20 feet and requires seven to ten days to complete. (This is called "one setting"). GeoSafe Corporation has projected vitrification depths to 50 feet with the ultimate limiting factor being melt tonnage per setting. The system is then moved to a second setting where the vitrification process is repeated. This is continued until the entire contaminated soil or sludge volume on the site has been vitrified. The vitrified mass then cools over a period of several months to a year or more.

The basic configuration of the ISV process consists of an electrical network with four electrodes driven or pushed into or placed in drilled augered holes in the soil or sludge, a capture hood to collect fumes or gases from the setting and direct it to an off-gas treatment system, and the off-gas treatment system itself. The off-gas treatment system consists of a quench tower, pH-controlled venturi scrubber, mist eliminator, heater (temperature controller), HEPA filters, and carbon adsorbers.

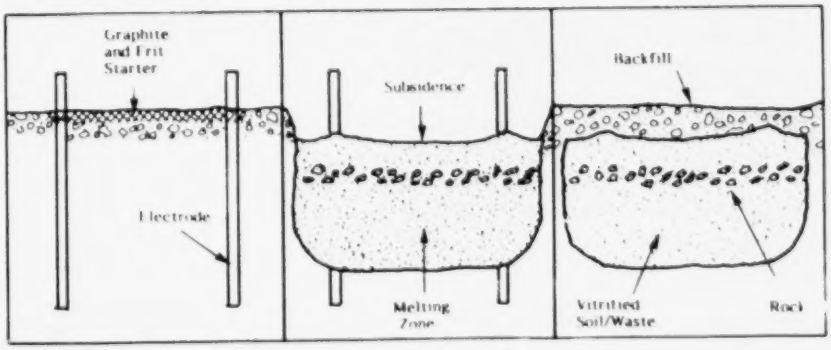

Figure 1. In-situ vitrification process.

The ISV process shares the same process control requirements as other thermal processes that convert hazardous materials into gaseous or vapor form. It is necessary to monitor the process to ensure that the off-gas treatment equipment is properly performing. Because of the high temperature of the melt, the great majority of gases evolving from the melt have been pyrolyzed into low molecular weight molecules or into diatomic gases that do not pose significant hazard to workers or the environment. However, the possibility exists for a small amount of hazardous materials to volatilize from the process; these must be treated by the off-gas treatment system to prevent an uncontrolled release to the environment.

WASTE APPLICABILITY: The ISV process can potentially be used to destroy or volatilize organics and/or immobilize inorganics in contaminated soils or sludges. ISV can be performed on saturated soils, but the initial application of current will be used to volatilize the moisture in the soil or sludge in the vicinity of a starter path of glass frit and graphite. Once this is done, the vitrification process begins. Sludges must contain a sufficient amount of glass-forming material (non-volatile, non-destructible solids) to produce a molten mass that will destroy, remove, or immobilize the organic and inorganic pollutants.

The ISV process is limited by (1) the presence of groundwater in the contaminated soil or sludge with a permeability of greater than 1×10^{-4} cm/sec, (2) the presence of buried metals in excess of 5 percent of the melt weight, and (3) the ability to maintain a negative pressure on the off-gas collection hood by the off-gas treatment system, and (4) the amount and concentration of the combustible organics present in the soil or sludge. Each of these limitations should be addressed based on site-specific conditions.

STATUS: The ISV process has been demonstrated at full-scale on radioactive wastes at the Department of Energy's Hanford Nuclear Reservation; pilot tests have also been performed on PCB wastes, industrial lime sludge, dioxins, metal plating wastes and other solid combustibles and liquid chemicals. Identification of a site for this technology demonstration is currently underway.

FOR FURTHER INFORMATION:

EPA Project Manager:
Jonathan G. Herrmann
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7839
FTS: 684-7839

Technology Contact:
James E. Hansen
GeoSafe Corporation
303 Parkplace, Suite 126
Kirkland, Washington 98033
206-822-4000

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

HAZCON, INC.

TECHNOLOGY DESCRIPTION: The solidification/stabilization technology mixes hazardous wastes, cement, water and an additive called Chloranan. Chloranan, a nontoxic chemical, encapsulates organic molecules, rendering them ineffective in retarding or inhibiting solidification. This treatment technology immobilizes the contaminants from soils by binding them into a concrete-like, leach-resistant mass.

After contaminated soil is excavated and screened out for oversized material, it is fed to a mobile field blending unit to treat the wastes (Figure 1). The unit consists of soil and cement holding bins, a Chloranan feed tank and a blending auger to mix the waste and pozzolanic materials (portland cement, fly ash or kiln dust). Then, water is added as necessary, and the resultant slurry is allowed to harden before disposal. The treated output are the contaminants bound by encapsulation into a hardened, concrete-like mass. For the treatment of large volumes of waste, larger blending systems are also available.

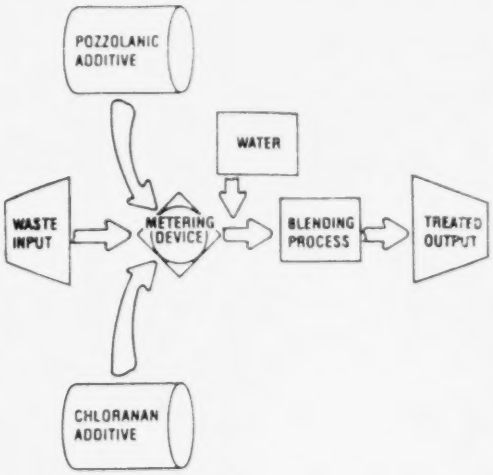

Figure 1. Solidification/stabilization process diagram

WASTE APPLICABILITY: This technology is suitable for soils and sludges contaminated by organic compounds, heavy metals, oil and grease.

STATUS: A former oil reprocessing plant containing high levels of oil and grease along with volatile and semi-volatile organics, PCBs, and heavy metals in Douglassville, Pennsylvania, was selected for demonstration testing using this technology. The Field Demonstration occurred October 1987. A Final Report was completed in September 1988, on the test results for six wastes stabilized at Douglassville.

DEMONSTRATION RESULTS: The comparison of the soil, 7-day and 28-day sample test results were generally favorable. The physical test results were very good, with unconfined compressive strength between 220 to 1570 psi. Very low permeabilities were developed (good) and the porosity of the treated wastes were moderate. Durability test results were very good, there was no change in physical strength after the wet/dry and freeze/thaw cycles. The microstructural analyses seemed to indicate possible sample degradation in the future. The 210-day sample core and future sample core testing will confirm or deny these projections. There was a waste volume increase of about 120%. By using less stabilizer smaller volume increases can be obtained, but lower strengths will result. There is an inverse relationship between physical strength and the waste organic concentration.

The results of the leaching tests were mixed. The TCLP results of the stabilized wastes were very low; essentially all values of metals, volatile organics and semi-volatile organics were below 1 ppm. Lead leachate concentrations dropped by a factor of 200 from the untreated soil results to below 100 ppb. Volatile and semi-volatile organic concentrations, however, did not change from the untreated soil TCLP. Oil and grease concentrations were greater in the treated waste TCLPs than the untreated waste, from less than 2 ppm up to 4 ppm. PCBs could not be detected (<1 ppb) in the TCLP leachates for either the treated or untreated wastes.

FOR FURTHER INFORMATION:

EPA Project Manager:
Paul R. de Percin
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7797
FTS: 684-7797

Technology Contact:
Ray Funderburk
HAZCON, Inc.
P.O. Box 947
Katy, Texas 77492
713-934-4500

EPA Technology Profile
Demonstration Program
SITE SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION
November 1988

HAZTECH

TECHNOLOGY DESCRIPTION: The electric infrared incineration technology (originally developed by Shirco Infrared Systems, Inc. of Dallas, Texas) is a mobile thermal processing system which uses electrically powered silicon carbide rods to bring the organic waste to combustion temperatures and then, to incinerate any remaining combustibles in an afterburner. The mobile system is comprised of four components: the electric-powered infrared primary chamber, a gas-fired secondary combustion chamber, an emission control system, and a process management and monitoring control center.

Waste is fed into the primary chamber on a wire mesh conveyor belt and exposed (at high temperatures of up to 1850°F) to infrared radiant heat provided by the horizontal rows of electrically-powered silicon carbide rods above the belt (Figure 1). A blower provides air at selected locations along the belt and can be used to control the burning rate of the waste feed and its location while burning on the belt.

The ash material which drops off the belt in the primary chamber is quenched by water sprays. This quench is scrubber water effluent and is used to reduce the amount of scrubber water effluent for disposal or reprocessing. The ash is then screw conveyed out of the primary chamber into the ash hopper where it is removed to a holding area, analyzed for PCB content, and then piled in a new location away from the processing area, after the PCB content is determined to be less than 1 ppm.

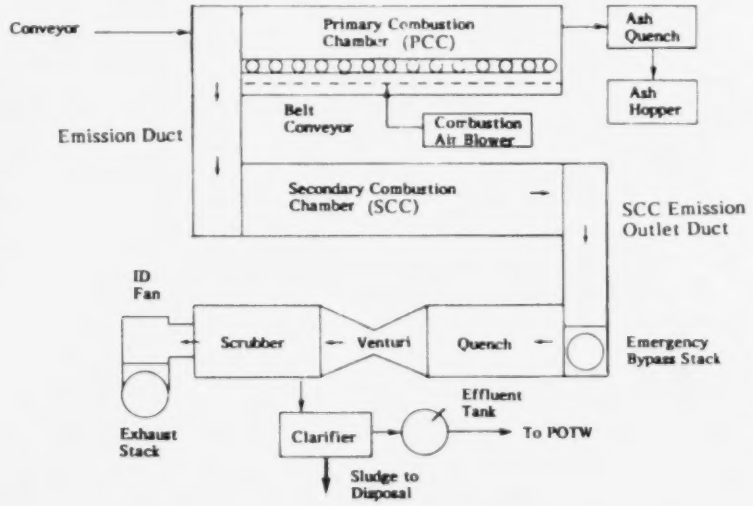

Figure 1. Peak Oil incineration unit process diagram.

Gaseous volatiles from the primary chamber flow into the secondary chamber which at higher temperatures provides residence time, turbulence and supplemental energy (if required) to destroy these gases. Gases from the secondary chamber are ducted through the emissions control system and then exhausted via a stack. An emergency stack is installed prior to the venturi scrubber system so that if the temperature control system and its interlocks were to fail, then the emissions control system would not be melted by the hot gases.

In the emissions control system, the particulates are removed in a venturi section. Acid vapor is neutralized in a packed tower scrubber, and then an induced draft blower draws the cleaned gases from the scrubber into the free standing exhaust stack.

The scrubber liquid effluent then flows into a clarifier where scrubber sludge settles out for disposal. Finally, the scrubber effluent flows to an effluent tank, through an activated carbon filter for reuse, or to a POTW tank for disposal.

WASTE APPLICABILITY: This technology is suitable for organic wastes contained in soils or sediments. Liquid organic wastes can also be handled once they are mixed with sand or soil.

STATUS: Report and summary was published in September 1988. The EPA document number is EPA 540/2-88/002.

FOR MORE INFORMATION:

EPA Project Manager:
Howard O. Wall
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7691
FTS: 684-7691

Technology Contact:
Mark de Lormier
Ecova Corporation
12790 Merit Drive, Suite 202
Dallas, Texas 75251
214-404-7540

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

INTERNATIONAL WASTE TECHNOLOGIES

TECHNOLOGY DESCRIPTION: This in-situ stabilization technology immobilizes organic and inorganic compounds in wet or dry soils by using reagents (additives) to polymerize with the soils and sludges producing a cement-like mass. Two basic components of this technology are the Geo-Con/DSM Deep Soil Mixing System, a system capable of delivering and mixing chemicals with the soil in-situ, and the batch mixing plant that supplies the proprietary treatment chemicals (Figure 1).

The Geo-Con/DSM Deep Soil Mixing System, incorporating mechanical mixing and injection, consists of one set of cutting blades and two sets of mixing blades attached to a vertical drive auger, which rotate at approximately 15 rpm. Two conduits in the auger allow for the injection of the additive slurry and supplemental water. Additive injection is on the downstroke, with further mixing occurring upon auger withdrawal. The treated soil columns, whose diameter is 36 inches, are positioned to provide an overlapping pattern. In each sector, alternating primary and secondary soil columns exist, with all primary columns prepared before the secondary columns are augered.

The developer states that their proprietary additive generates a complex crystalline connective network of inorganic polymers and that the structural bonding in the polymer is mainly covalent. Furthermore, in the process, there is a two-phased reaction in which the contaminants are complexed first in a fast-acting reaction and then in a slow-acting reaction where the building of macromolecules continues over a long period of time. For each type of waste, the quantity of additives used varies and must be optimized.

WASTE APPLICABILITY: This technology can be applied to soils, sediments, and sludge-pond bottoms contaminated with organic compounds and metals.

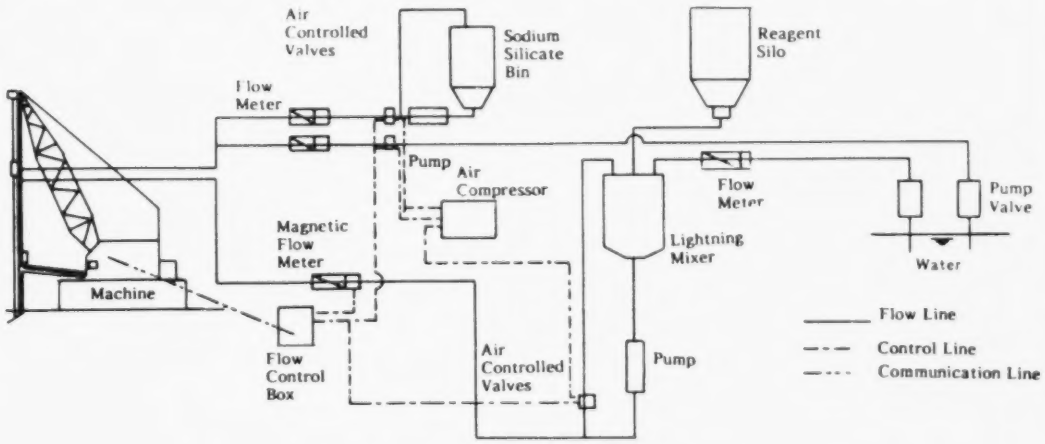

Figure 1. In-situ stabilization batch mixing plant process diagram.

STATUS: The technology has been laboratory tested on soils containing PCBs, PCPs, refinery wastes, and chlorinated and nitrated hydrocarbons. Under the auspices of the Superfund Innovative Technology Evaluation (SITE) Program, this technology combined with the use of the Geo-Con soil injection and mixing equipment has been demonstrated at a PCB-contaminated site in Hialeah, Florida. The demonstration occurred in April and May of 1988. The final report will be published in April 1989.

FOR FURTHER INFORMATION:

EPA Project Manager:
Mary K. Stinson
U.S. EPA
Risk Reduction Engineering Laboratory
Woodbridge Avenue
Edison, New Jersey 08837
201-321-6683
FTS: 340-6683

Technology Contact:
Jeff P. Newton
International Waste Technologies
150 North Main Street, Suite 910
Wichita, Kansas 67202
316-269-2660

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

MOTEC, INC.

TECHNOLOGY DESCRIPTION: The liquid-solid contact digestion (LSCD) technology involves organic wastes which are placed in a high energy environment and solubilized into the aqueous phase, thus allowing microorganisms to degrade or detoxify organic constituents. The system uses two or three portable tank digesters or lagoons. The portable system has three phases: (1) Primary Contact or Mixing Phase, (2) Primary Digestion Phase, and (3) Polishing Phase.

This technology, used for the destruction of toxic organic compounds, is simple in operation and allows mass-balance determinations. Its treatment time may be a month or more depending on the type of contaminants, concentrations and temperature. The technology may also be a source of air emissions.

In the primary contact phase (Figure 1), mixers (aerators, in many cases) are used to mix the influent waste material containing between 2 and 800,000 ppm of total organic carbon, such as sludge or soil, and to achieve a 20-25 percent solids concentration. Make-up water is added (80 percent by volume) either from the contaminated source or fresh water source. Emulsifying chemicals are added, and pH is adjusted to increase the solubility of the organic phase.

After the organics have solubilized into the liquid phase, the "batch" mixture is transferred to primary digestion tanks or cells where pH is adjusted, acclimated seed bacteria is added, and aerobic biological oxidation is started. During this phase, most of the biological oxidation occurs. Generally, when the biodegradable organic concentration is reduced to a level of 50 to 100 ppm, the "batch" is transferred to the polishing cell for final treatment; the process is operated in a sequential mode.

Once the pH has been readjusted in the polishing cell, cometabolites and nutrients are added to maintain and enhance the biomass which degrade organic constituents to target concentration levels. Because the system runs on a

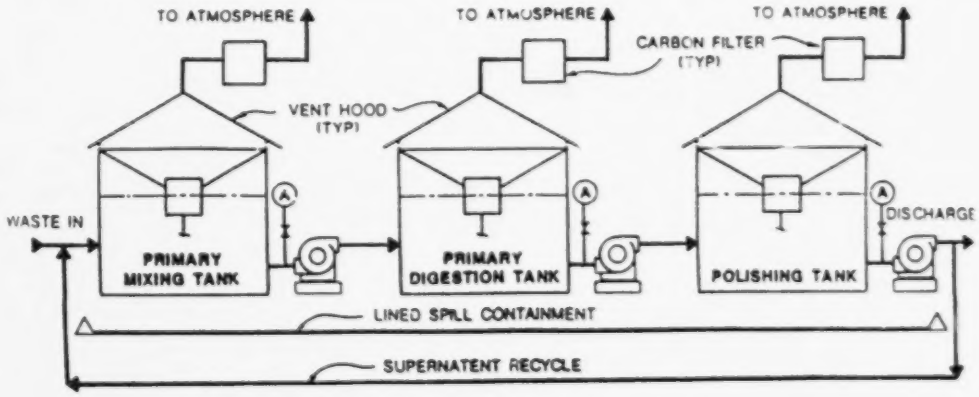

Figure 1 LSCD process flow diagram

negative water balance, make-up water is added throughout the process. Following the completion of the "batch", the supernatant from the polisher is recycled to the primary contact tank or cell, and the sludge is treated in land farms/ reactors on site.

WASTE APPLICABILITY: The technology is suitable for treating halogenated and nonhalogenated organic compounds, PCBs, dioxins, and pesticides. However, it is not suitable for inorganic-laden wastes. LSCD has been demonstrated on liquids, sludges, and soils with high organic concentrations.

STATUS: A demonstration project is proposed to test this technology by processing 50 to 100 cubic yards of contaminated soil over a 3-month period. The soil will be from a wood preserving facility. The demonstration is planned for April of 1989.

FOR FURTHER INFORMATION:

EPA Project Manager:
Eugene F. Harris
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7862
FTS: 684-7862

Technology Contact:
John Bogart
MOTEC, Inc.
Clearview Plaza Mall
P.O. Box 338
Mt. Juliet, Tennessee 37122
615-754-9626

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

OGDEN ENVIRONMENTAL SERVICES

TECHNOLOGY DESCRIPTION: The Circulating Bed Combustor (CBC) uses high air velocity and circulating solids to create a highly turbulent combustion zone for the efficient destruction of toxic chemicals and the retention of resultant acid vapors. It is based on the advanced fluidized-bed incineration system and is distinct from conventional fluidized beds since it operates at a higher velocity air flow and produces a higher combustion efficiency.

The circulating combustor technology is applicable to solids, liquids and soils. This technology uses high velocity air to entrain circulating solids in a highly turbulent combustion loop. Waste material and limestone are fed into the combustion loop along with recirculated bed material from the hot cyclone (Figure 1). Limestone addition provides for quick neutralization of acid gas. NO_x and CO emissions are kept low by effective mixing and relatively low combustion temperatures (1600°F). Hot gases pass through a convective gas cooler and a baghouse before exhausting to the atmosphere.

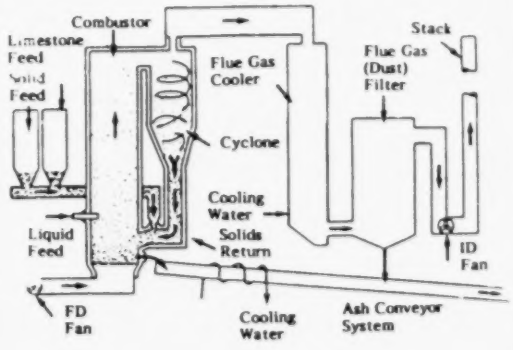

Figure 1. CBC process diagram.

WASTE APPLICABILITY: CBC technology may be applicable to hydrocarbon wastes, soils and lagoons containing nazardous and non-hazardous wastes, oily sludges, and munitions and chemical agents. It is said to be capable of treating feedstock contaminated with PCBs, PCPs, halogenated wastes, chlorinated sludges, aniline still-bottoms, oily and solvents sludges, among others. It has also been applied, during trial tests, to wastes such as carbon tetrachloride, freon, malathion, trichloroethylene, dichlorobenzene, aromatic nitrate, and PCBs.

STATUS: The CBC is one of only seven incinerators nationwide permitted to burn PCBs. A pilot plant exists for treatability studies and two field-scale units (100 tons/day) have been constructed with two more units to be constructed in 1989.

Discussions about using the McColl Superfund site for demonstration of the CBC technology are underway. Some opposition issues still need to be addressed and resolved.

FOR FURTHER INFORMATION:

EPA Project Manager:
Joseph McSorley
U.S. EPA
Air & Energy Engineering Research Laboratory
Alexander Drive
Research Triangle Park, NC 27711
919-541-2920
FTS: 629-2920

Technology Contact:
Brian Baxter
Ogden Environmental Services
10955 John J. Hopkins Drive
San Diego, California 92121
619-455-2613

EPA Technology Profile
Demonstration Program
SITE SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION
November 1988

RESOURCES CONSERVATION COMPANY

TECHNOLOGY DESCRIPTION: The Basic Extraction Sludge Treatment (B.E.S.T.) process is a chemically enhanced separation technique for breaking difficult-to-handle oily sludges into oil, water and solids. To break oil-water emulsions and release bonded water and oil from the sludge, an aliphatic amine [usually triethylamine (TEA)] is used. Since TEA is completely miscible with water below 65°F, the B.E.S.T. process takes advantage of this solubility property by mixing refrigerated recycled TEA with the oily sludges. Pretreatment requirements can vary widely and are dependent on the raw feed sludge state. Feed materials must be screened to a one-fourth inch diameter size and must either be pumpable or be able to be slurried into a pumpable mass. Acidic materials must be neutralized, and feed components tested to assure that reactions between the TEA solvent and feed components do not occur, or emulsifiers or other separation interfering compounds are not present. pH must be adjusted to a range of 7.0 to 12.0, as TEA at low pHs can form salts and would be lost in the water phase. Laboratory tests of wastes are required to assure optimum extraction performance. Post-treatment requirements can also vary between applications. Some product oil/organic, water, or solids upgrading may or may not be needed depending on the intended disposition of these materials.

The B.E.S.T. process is essentially a fully-enclosed system except at the product residue outlets. After the influent sludge is fed into the first mixing chamber (Figure 1) and mixed with TEA, the solvent immediately turns the mixture

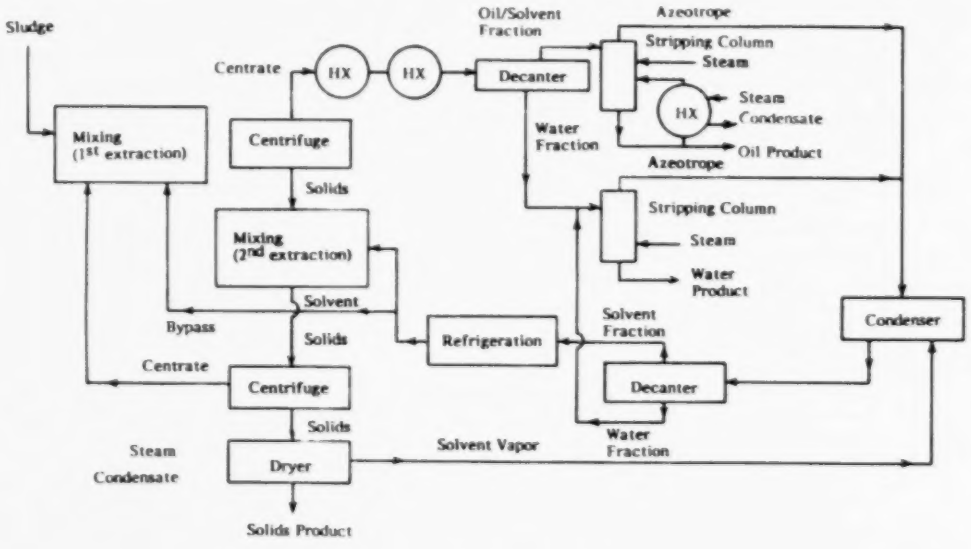

Figure 1. BEST process flow diagram.

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into a homogeneous solution. Since the temperature is kept below the solubility line, solids are no longer bonded by the oil/water emulsion (that was part of the original sludge) and are released from the solutions. Once the solids are removed, the temperature of the liquid fraction (which contains the oil, water and solvent) is heated above the solubility point, and the water separates from the oil and the solvent. The last step in the process is to remove the solvent from the oil using distillation.

Solids are separated from the liquid mass generally by a solid bowl decanter centrifuge under a force of several thousand g's. This type of machine ensures a clear centrate and a good oil product. The solid cake from the first centrifuge (which normally contains about 50 percent solids by weight) is rewashed with solvent in a mix tank and recentrifuged in a second solid bowl decanter. The oil content in the cake is reduced to 1 percent liquid, and in the cake is TEA which is driven off in a steam-heated, hollow-disk, indirect heater. The drying step requires one eighth the energy than if water was being evaporated alone.

The centrate that leaves the first centrifuge contains all the oil and water extracted from the raw sludge. The centrate is heated in a series of heat exchangers to temperatures above the solubility limit, so that two phases now exist. The two phase stream is sent to a decanter where the lower water fraction is separated and sent to a stripping column to remove residual solvent. The top fraction leaving the decanter is primarily the solvent-containing oil extracted from the raw sludge. This fraction is sent to a second stripping column where the solvent is recovered and the oil is discharged. Recovered solvent is refrigerated and recycled back to the front end of the process.

WASTE APPLICABILITY: This technology can be applied to difficult-to-handle oily sludges, oils, or PCB-contaminated soils and sediment. No special climatic restrictions to the B.E.S.T. system exist, although system modifications such as steam tracing or handling of frozen feed materials may be required in freezing climates.

STATUS: Currently, a demonstration is proposed for a site which is still unidentified. This technology was used by Region 4 to conduct a removal action at the General Refining site near Savannah, Georgia.

FOR FURTHER INFORMATION:

EPA Project Manager:
Edward R. Bates
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7774
FTS: 684-7774

Technology Contact:
Paul McGough
Resources Conservation Company
3006 Northup Way
Bellevue, Washington 98004-1407
206-828-2400

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

RETECH, INC.

TECHNOLOGY DESCRIPTION: The Centrifugal Reactor is a thermal treatment technology that uses the heat from a plasma torch to create a molten bath which is used to detoxify contaminated soils. Organic contaminants are vaporized and react at very high temperature to form innocuous products. Solids melt and are incorporated into the molten bath. Metals are retained in this phase, and when cooled, this phase is a nonleachable matrix.

In the diagram of the centrifugal reactor (Figure 1), contaminated soils enter the reactor through the bulk feeder, where they are processed as described above. The interior of the reactor (the reactor well) rotates during waste processing. Centrifugal force created by this rotation prevents waste and molten material from flowing out of the reactor through the bottom. It also helps to transfer heat and electrical energy evenly throughout the molten phase. Periodically, the reactor is emptied. Molten solids fall into the collection chamber where they are allowed to solidify. Gases travel through the secondary combustion chamber where they remain at high temperature for an extended period of time. This allows for further thermal destruction of any organics remaining in the gas phase. Downstream of the secondary combustion chamber, the gases pass through a series of air pollution control devices designed to remove particulates and acid gases. In the event of a process upset, a surge tank has been installed to allow for the reprocessing of any off-gases produced.

WASTE APPLICABILITY: Liquid and solid organic compounds can be treated by this technology. It is most appropriate for soils and sludges contaminated with metals and hard-to-destroy organic compounds.

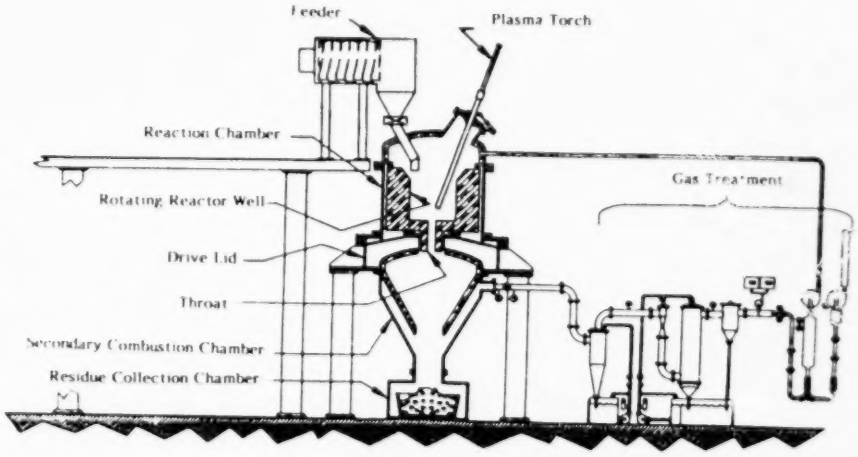

Figure 1. Centrifugal reactor.

STATUS: A demonstration is planned for early next year at a Department of Energy research facility in Butte, Montana. During the demonstration, the reactor will process approximately 4000 pounds of waste at 100 pounds per hour. Sampling of all feed and effluent streams will be carried out to assess the performance of this technology. A report on the demonstration project will be available after its completion.

FOR FURTHER INFORMATION:

EPA Project Manager:
Laurel Staley
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7881
FTS: 684-7881

Technology Contact:
R.C. Eschenback
Retech, Inc.
P.O. Box 997
100 Henry Station Road
Ukiah, California 95482
707-462-6522

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

SANITECH, INC.

TECHNOLOGY DESCRIPTION: This ion-exchange technology involves the use of ion-exchange-like materials which process and selectively remove toxic heavy metals from contaminated ground or surface waters. This technology is a liquid waste treatment system consisting of a prefilter followed by an ion-exchange bed. The exchange medium is described as silica particles coated with a selective ion-exchange compound; this medium removes metals from the liquid waste stream and is subsequently regenerated with acid. In the process, only one-third of the bed volume of diluted reagent (HCl or H_2SO_4) is required to regenerate the Devoe-Holbein (DH) composition resin (Figure 1). Fresh water rinse "chases out" concentrated metal to a recovery tank. Then, concentrated metal solution can be sent back to a plating/recovery operation.

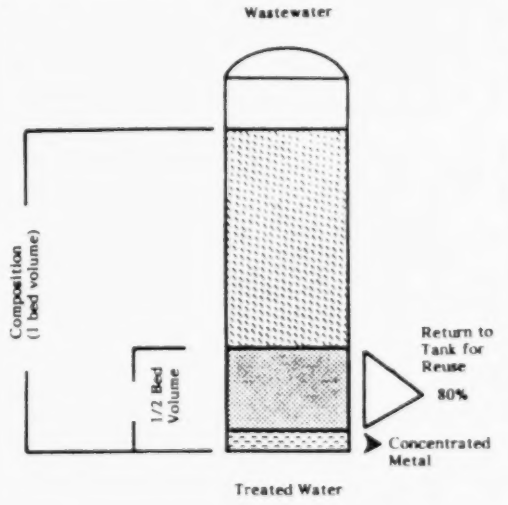

Figure 1. Wastewater process unit column showing regeneration.

The treatment system can be mobile, treating 3 to 4 gallons or up to 12 gallons per minute of liquid wastes. A removal efficiency of greater than 99 percent and effluent qualities of less than 0.1 ppm of a metal have been reported.

WASTE APPLICABILITY: This technology can be used to treat contaminated groundwaters or surface waters laden with toxic heavy metals such as zinc, chrome III and VI, nickel, cadmium, lead, copper, and mercury.

STATUS: Currently, a demonstration site is still unselected.

FOR FURTHER INFORMATION:

EPA Project Manager:
Richard Traver
U.S. EPA
Risk Reduction Engineering Laboratory
Woodbridge Avenue
Edison, New Jersey 08837
201-321-6677
FTS: 340-6677

Technology Contact:
Sidney G. Nelson
Sanitech, Inc.
1935 East Aurora Road
Twinsburg, Ohio 44087
216-425-2354

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

SEPARATION AND RECOVERY SYSTEMS, INC.

TECHNOLOGY DESCRIPTION: This lime-based technology has been proven to effectively fix sludges with a high level of hydrocarbons. No hazardous materials are used in the process. The lime, and other minor chemicals, are specially prepared to significantly improve their reactivity and other key characteristics.

In this process, sludge is removed from the waste pit and mixed with lime in a separate blending pit. The fixation reactions occur over a twenty minute period and are exothermic. The temperature of the material in the blending pit rises for a very brief time to around 100°C, and some steam is evolved. After twenty minutes, almost all of the material has been fixed. The reactions are completed over the next few days. The fixed material is stored in a product pile until the waste pit has been cleaned. Then, the product is returned to the pit and compacted to 10^{-10}cm/sec. The volume of the waste is only increased by 30 percent. This process uses conventional earth moving equipment and is, therefore, highly mobile.

WASTE APPLICABILITY: The technology is applicable to acidic sludges containing at least 5 percent hydrocarbons (typical of sludges produced by re-manufacturing lube oils). The technology can also stabilize waste containing up to 80 percent organics. Claims are made that metals are immobilized, but the process tolerates only low levels of mercury and moderate levels of lead.

STATUS: Currently, the EPA is in the process of locating a suitable site for the demonstration of this technology.

FOR FURTHER INFORMATION:

EPA Project Manager:
Richard Valentinetti
U.S. EPA (RD-681)
401 M Street, SW
Washington, D.C. 20460
202-382-5753
FTS: 382-5753

Technology Contact:
Joseph de Franco
Separation and Recovery Systems, Inc.
16901 Armstrong Avenue
Irvine, California 92714
714-261-8860
TELEX: 68-5696

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EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

SILICATE TECHNOLOGY CORPORATION

TECHNOLOGY DESCRIPTION: This solidification/stabilization technology using silicate compounds are two separate technologies that: (1) fix and solidify the organics and inorganics contained in contaminated soils and sludges, and (2) remove organics from contaminated groundwaters. The primary technology, solidification, utilizes a proprietary reagent, FMS silicate, to selectively adsorb organic contaminants prior to mixing the waste with cementitious material to form a high-strength, non-leaching monolith. The second technology, stabilization, uses the same reagent in conjunction with granular activated carbon to remove organics from the water streams. The resulting waste material is then solidified by the first process.

The soil solidification process coordinates a systems engineering approach with standard construction practices for application to contaminated wastes. Since the type and dosage of reagents depend upon the waste's characteristics, treatability studies and site investigations need to be conducted to determine required reagent formulations for the site. The process begins with the pretreatment of the contaminated material where the coarse material is separated from fine material (Figure 1). The coarse material is then sent through a shredder which cuts the material to the size required for the solidification technology. The fines and shredded hazardous material are conveyed into a batch plant where the treatment reagent is applied. Here, the hazardous material is weighed, and the proportional amount of treatment reagents are added. This mixture is conveyed to a concrete mixing truck where hydration water is added and thorough blending occurs. The concrete mixing truck then places the treated material in a confining pit on site for curing.

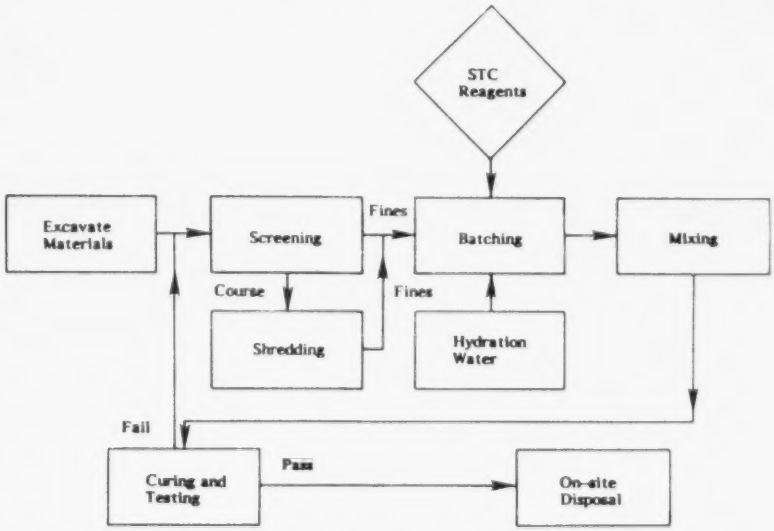

Figure 1. Contaminated soil process flow diagram.

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The contaminated water process uses a self-contained mobile filtration pilot facility for the decontamination of organic contaminated water. This patented process uses reagents for the removal of high molecular weight organics along with granulated activated carbon for the removal of low molecular weight organics. The process consists of passing the contaminated water through a column filter containing the reagent. The high molecular weight organics are removed from the water in this step. The effluent from this column filter is then passed through a second column filter containing granulated activated carbon.

WASTE APPLICABILITY: This combined technology can be applied to metals in soils and sludges along with cyanides, fluorides, arsenates, ammonia, chromates, selenium, etc., in unlimited concentrations. Higher weight organics in groundwaters and soils and sludges including halogenated, aromatic and aliphatic compounds can also be treated by this combined process. However, the process is not as successful on low molecular weight organics such as alcohols, ketones and glycols.

STATUS: A demonstration of this combined technology should occur between April 1988, and August 1989, at the Tacoma Tar Pits Superfund Site in Tacoma, Washington.

FOR FURTHER INFORMATION:

EPA Project Manager:
Edward R. Bates
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7774
FTS: 684-7774

Technology Contact:
Steve Pegler
Silicate Technology Corporation
Scottsdale Technology Center
14455 North Hayden Road, Suite 218
Scottsdale, Arizona 85260
602-948-1300

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

SOLIDITECH, INC.

TECHNOLOGY DESCRIPTION: This solidification/stabilization process incorporates a proprietary reagent, URRICHEM, into a mixture of the waste material and pozzolanic fly ash, kiln dust, or portland cement. Dispersing the URRICHEM reagent throughout the mixed batch achieves complete blending of all ingredients. A multiphase cementation process coats large particles with pozzolanic materials, links organic and inorganic components, and seals pore spaces within the solidified matrix. Hazardous constituents contained in the waste slurry are chemically and physically immobilized. The reagent formula, other additives, and mixing proportions are optimized for each specific waste type.

The process begins (Figure 1) when waste is placed in a mixer by pump or other means, and waste samples are obtained for testing and quality control purposes. URRICHEM reagent is added to the waste in the mixer and thoroughly dispersed by blending. Pozzolan is then added in predetermined proportions and blended. Finally, the waste is removed from the mixer and pumped or transported to a storage/disposal site or containers, and samples are again obtained for quality control purposes.

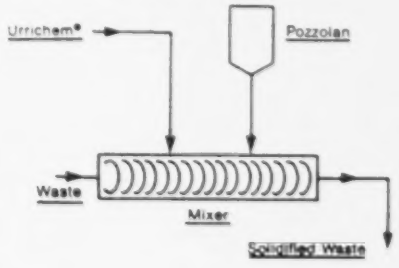

Figure 1. Basic process flow diagram.

WASTE APPLICABILITY: This technology can be applied to a broad range of organic and inorganic slurries and to bulk hazardous liquids prior to disposal (i.e., landfilling). However, wastes containing radioactive nuclides, explosives, and/or high levels of strong inorganic acids (HCl or H_2SO_4) are not suitable for this process.

STATUS: This technology has been tested on several dozen waste types on a bench scale. It is in use at full scale by a deep-well injection company to stabilize oily waste residues. A location for demonstration of this technology has been tentatively selected, and the demonstration is scheduled for late in 1988.

FOR FURTHER INFORMATION:

EPA Project Manager:
Walter E. Grube, Jr., Ph.D.
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7798
FTS: 684-7798

Technology Contact:
Carl Brassow
Soliditech, Inc.
6901 Corporate Drive
Suite 215
Houston, Texas 77036
713-778-1800

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

TERRA VAC, INC.

TECHNOLOGY DESCRIPTION: This in-situ vacuum extraction technology is a process for the removal and venting of volatile organic compounds (VOCs) from the vadose or unsaturated zone of soils. Often, these compounds can be removed from the vadose zone before they have a chance to contaminate groundwater. In using this technology, subsurface organic contaminants are "vacuumed up" via a well, vapor/liquid separated, and then exposed to activated carbon before the "vapor" is allowed to be released into the atmosphere.

The technology uses readily available components such as extraction and monitoring well(s), manifold piping, vapor/liquid separator, vacuum pump, and emission control equipment, such as activated carbon canisters. Once a contaminated area is completely defined, an extraction well (or wells) is installed (depending upon the extent of contamination) and is connected by piping to a vapor/liquid separator device (Figure 1). A vacuum pump draws the subsurface contaminants through the well, separator device, and an activated carbon canister before discharge of the air streams is allowed to the atmosphere. Subsurface vacuum and soil vapor concentration are monitored via vadose zone monitoring wells.

The technology does not require highly trained operators or soil excavation, and it also is not depth limited. The technology works best when it is applied towards the remediation at sites which are contaminated by liquids having high vapor pressures. However, the process is limited in applicability; diffusion rates through dense soils (such as compacted clays) are much lower than through sandy soils, and if activated carbon is used, then spent carbon must be processed. In addition, depending on the soil type and the depth to groundwater, the radius of influence of a single extraction well can range from tens to hundreds of feet. Typical contaminant recovery rates also range between 20 and 2500 pounds per day and are a function of volatility of the organic compound recovered. Therefore, the more volatile the organic compound, the faster the process works. The developer also states that the process is more cost effective where contaminated soils are predominantly above the water table, although systems have been designed for vapor and groundwater recovery.

WASTE APPLICABILITY: This technology is applicable to organic compounds that are highly volatile at ambient temperatures in soils and groundwater.

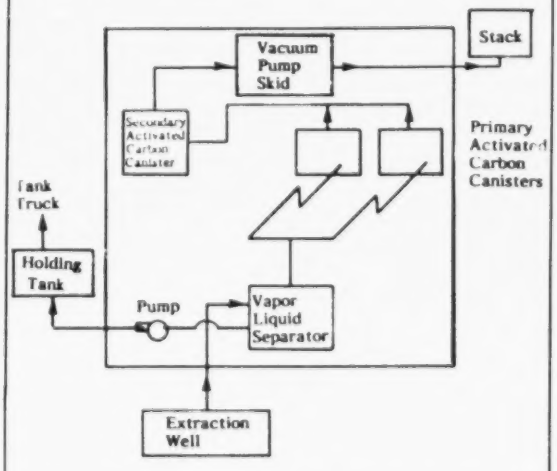

Figure 1. Process diagram for in-situ vacuum extraction.

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STATUS: This in-situ vacuum extraction process is being utilized in many locations across the United States, such as the Verona Wells Superfund Site (U.S. EPA Region 5, Battle Creek, Michigan) — which mainly contains trichloroethylene contamination — and several gasoline station spills. Although it was first demonstrated at a Superfund site in Puerto Rico where carbon tetrachloride had leaked from an underground storage tank, a field demonstration of the process was performed under the auspices of the Superfund Innovative Technology Evaluation (SITE) Program and was conducted at the Valley Manufactured Products Company, Inc. property, which is a part of the Groveland Wells Superfund site in Groveland, Massachusetts. This site has been mainly contaminated by trichloroethylene, which was used as a degreasing agent by the machine shop that is still in operation at the site. The technical report from this demonstration project will be published in April 1989.

FOR FURTHER INFORMATION:

EPA Project Manager:
Mary K. Stinson
U.S. EPA
Risk Reduction Engineering Laboratory
Woodbridge Avenue
Edison, New Jersey 08837
201-321-6683
FTS: 340-6683

Technology Contact:
James Malot
Terra Vac, Inc.
356 Fontaleza Street
P.O. Box 1591
San Juan, Puerto Rico 00903
809-723-9171

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

TOXIC TREATMENTS, INC.

TECHNOLOGY DESCRIPTION: A transportable treatment unit called a "Detoxifier" is used for in-situ steam and air stripping of volatile organics from contaminated soil during site remediation. Drills are modified to allow the injection of steam and air into the soil through the cutting blades (Figure 1). The ground area being drilled is covered by a containment system to trap and recover the stripped volatiles.

Two main components of the on-site treatment equipment are the process tower and process train. The process tower contains two counter-rotating drills, each having a modified cutting bit 5 feet in diameter which is capable of operating to a 27 foot depth. Each drill also contains two concentric pipes where the inner pipe is used to convey steam supplied by an oil-fired boiler at 450°F and 450 psig to the rotating cutting blades. The outer pipe conveys air at approximately 300°F and 250 psig to the rotating blades. In this process, steam is piped to the top of the drills and injected through the cutting blades. The steam heats the ground being remediated increasing the vapor pressure of the volatile contaminants and thereby increasing the rate at which they can be stripped. Both the air and steam serve as carriers to convey these contaminants to the surface. The shroud, a metal box designed to seal the process area above the rotating cutter blades from the outside environment, collects the volatile contaminants and ducts them to the process train. In the process train, the volatile contaminants and the water vapor are removed from the off-gas stream by condensation. The condensed water is separated from the organics by distillation, then filtered through activated carbon beds and subsequently used as make-up water to a wet cooling tower. Steam also is used to regenerate the activated carbon beds and acts as the source of heat for distillation of the volatile contaminants from the condensed liquid stream.

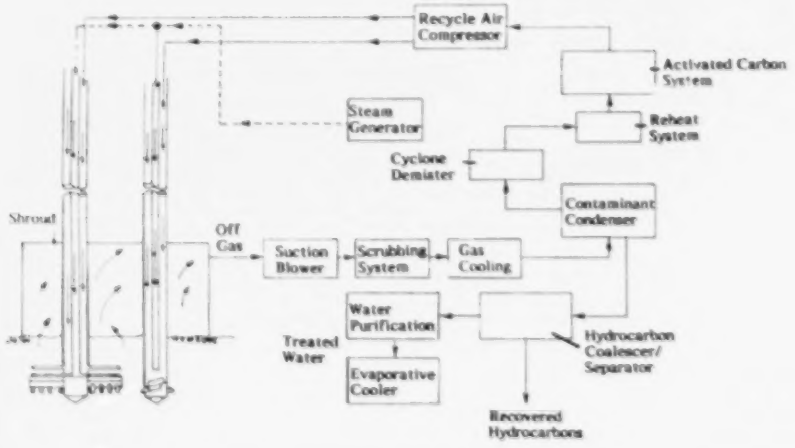

Figure 1. Typical detoxifer system process flow diagram.

WASTE APPLICABILITY: This technology may be applicable to the family of organic contaminants in soil which exhibit a sufficient partial pressure to enable their removal by a stripping process. Wastes from areas which have been exposed to hydrocarbons, solvents, or other volatile liquid contamination are also applicable. These contaminants may be remediated from soil without limitation due to concentration, viscosity, particle size, constituent volatility or constituent interference.

STATUS: A site in California has been selected as a demonstration site. A demonstration plan is in preparation. The field treatability study at the San Pedro site has been completed and a report submitted to the state of California. Final permit approval is pending. The U.S. EPA SITE Demonstration is scheduled for January/ February 1989.

FOR FURTHER INFORMATION:

EPA Project Manager:
Paul de Percin
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7797
FTS: 684-7797

Technology Contact:
A.P. Statham
Toxic Treatments, Inc.
901 Mariners Island Boulevard
Suite 315
San Mateo, California 94404
415-572-2994

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

ULTROX INTERNATIONAL

TECHNOLOGY DESCRIPTION: This ultraviolet (UV)/oxidation process using ozone (O_3) and hydrogen peroxide (H_2O_2) is suited for destroying toxic organic compounds, especially chlorinated hydrocarbons, in dilute concentrations in water. The process oxidizes toxic and/or refractory (those which are resistant to biological oxidation) compounds in concentrations measured in the ranges of parts per million or parts per billion, and is capable of reducing them to non-detectable levels. No residues, sludges or spent adsorbents are generated, in contrast to granular activated carbon, the usual competitive process.

The system consists of a reactor module, air compressor/ozone generator module and hydrogen peroxide feed system. It is skidmounted and portable and permits on-site treatment of a wide variety of solutions such as industrial wastewaters, groundwaters, and leachates. The reactor size is determined from the expected wastewater flow rate and the necessary "residence time" for contaminated water to remain in contact with the UV radiation and the oxidants. Approximate UV intensity and ozone/hydrogen peroxide dosages are determined from pilot-scale studies and are precisely controlled in the full-scale reactor.

In this process, influents flowing into the reactor (Figure 1) are simultaneously exposed to UV radiation, whereby ozone and/or hydrogen peroxide create a strong oxidizing environment for inducing photochemical oxidation of halogenated organic compounds. End products of the reaction are carbon dioxide, water and innocuous salts. Off gases from the reactor pass through a catalytic ozone decomposer unit, which reduces ozone levels to acceptable air quality standards before air venting. A catalytic unit can also be installed to destroy gaseous chlorinated VOCs stripped off in the reactor. Effluents from the reactor can be reused or di-

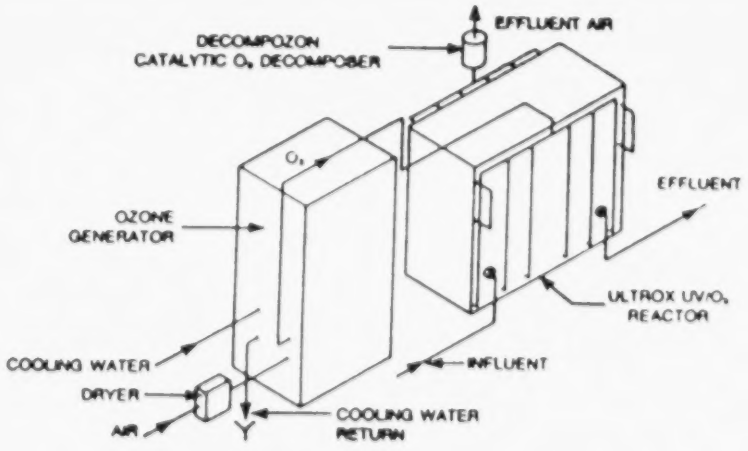

Figure 1. ULTROX® UV/O_3 process flow schematic.

rectly discharged to sewage treatment plants or receiving waters.

WASTE APPLICABILITY: This technology destroys organic compounds, including chlorinated hydrocarbons in dilute concentrations in water and has been previously demonstrated on site at various locations. Contaminated groundwater, industrial wastewaters and leachates containing trichloroethylene, perchloroethylene, methylene chloride, phenol, pentachlorophenol, miscellaneous pesticides and PCBs are suitable for this on-site treatment process.

STATUS: A proposed demonstration project for a Superfund site remediation of contaminated groundwater is scheduled to begin in mid 1989.

FOR FURTHER INFORMATION:

EPA Project Manager:
Norma Lewis
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7665
FTS: 684-7665

Technology Contact:
David B. Fletcher
Ultrox International
2435 South Anne Street
Santa Ana, California 92704
714-545-5557

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

WASTECHEM CORPORATION

TECHNOLOGY DESCRIPTION: The Volume Reduction and Solidification (VRS) system is used for volume reduction and stabilization of liquid or dried wastes. Depending upon the waste characteristics, various thermal pretreatment equipment may be used in combination with this technology.

In this process, waste liquid or sludge is transferred to either the batch mix tank or pretreatment equipment; any off-gas is drawn to the scrubber. As required in the batch mix tank, the waste sludge is fluidized. Then, the waste sludge (or dried solids) and asphalt are simultaneously fed to the extruder/evaporator unit where asphalt encapsulates the waste. Since this unit is a one-step volume reduction and solidification process, the waste/asphalt mixture is then discharged to a 55-gallon drum, where it solidifies. Distilled in the evaporation process, trace organics along with the water flow by gravity to an organic distillate detoxification tank. At a caustic-adjusted pH of 10.5 to 11.5, the distillate and off-gas produced are destroyed by ozone. Then, the residual trace organics in the detoxified distillate are removed by a carbon absorber/filter; the detoxified effluent is stored, analyzed, and discharged once permit requirements are met. The off-gas from the detoxification tank passes through a scrubber and then through an organic detoxification cell. Residual organics are also removed via an ozonation process and carbon absorber/filter prior to atmosphere release.

WASTE APPLICABILITY: This technology is versatile in that most liquid or dried waste is suitable for processing.

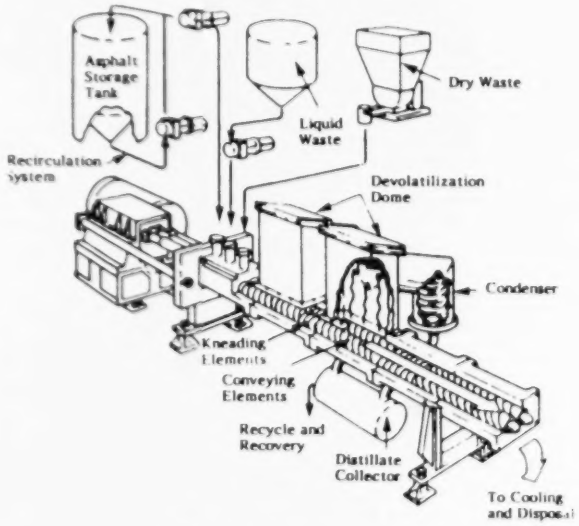

Figure 1. Mobile VRS™ system.

STATUS: The developer has decided to terminate the demonstration. Therefore, the demonstration of this technology will probably be deleted from the SITE 002 program. All the data developed to date will be included in a final report for EPA.

FOR FURTHER INFORMATION:

EPA Project Manager:
S. Jackson Hubbard
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7507
FTS: 684-7507

Technology Contact:
Hans Theyer
WasteChem Corporation
One Kalisa Way
Paramus, New Jersey 07652
201-599-2900

EPA Technology Profile
Demonstration Program
SITE SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION
November 1988

WESTINGHOUSE ELECTRIC CORPORATION

TECHNOLOGY DESCRIPTION: The pyroplasma process is based on the concept of pyrolyzing waste molecules using a thermal plasma field. The heart of the destruction system is a plasma torch which is entirely contained as a unit in a 48-foot tractor trailer and requires only 4160 volts, 3-phase power, water and sanitary sewer discharge lines. When configured as a mobile unit, the technology can be transported and used in emergency response to clean up hazardous material spills or to perform waste site cleanups.

The pyroplasma unit uses electric power across a colinear electrode assembly to produce an electric arc which causes an injected low pressure air stream to be ionized, forming a thermal plasma with temperatures in the 5,000-15,000 degree Celsius range. Waste feed introduced into the thermal plasma (Figure 1) causes the waste molecules to be completely dissociated into their atomic components because of the unique plasma properties for the breaking of molecular bonds. These atoms recombine in the reaction chamber to form non-toxic gases, typically carbon monoxide, nitrogen and hydrogen along with some methane and ethane. Acid gases (hydrogen chloride-HC1) formed from the destruction of chlorinated wastes and the subsequent combination of hydrogen and chlorine gases are neutralized and cooled in a wet scrubber with caustic soda. Particulate carbon produced is also removed in this stream. The product gas is drawn off by an induction fan and flared directly. It can also be routed to a combustor for heat recovery.

This technology requires highly trained operators. It may degrade arc and refractory materials due to the high temperatures, may have a durability problem, and is very sensitive to voltage drops and energy/mass balance of the system.

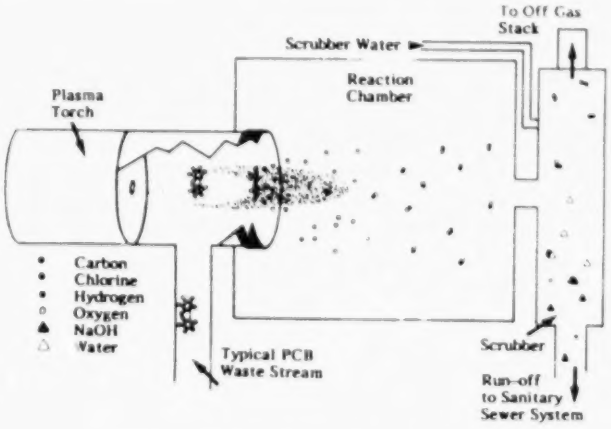

Figure 1. Plasma torch waste destruction process.

WASTE APPLICABILITY: This technology is suitable only for liquids or pumpable wastes and chlorinated organics, such as pesticides, wood preservatives (PCP, creosote compounds), and petroleum compounds.

STATUS: Currently, a 3 GPM (1 ton/hour) unit operating at 750 kW is available for the Demonstration Program. Even though dependable cost data are not yet available, preliminary estimates are that this technology will be comparable with conventional thermal systems, such as rotary kilns.

FOR FURTHER INFORMATION:

EPA Project Manager:
Eugene F. Harris
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7862
FTS: 684-7862

Technology Contact:
John F. Gross
Westinghouse Electric Corporation
Waltz Mill Site
P.O. Box 286
Madison, Pennsylvania 15663
412-722-5655

EPA Technology Profile
Demonstration Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

ZIMPRO/PASSAVANT, INC.

TECHNOLOGY DESCRIPTION: The powdered activated carbon treatment (PACT) process is a biological treatment process that incorporates physical adsorption using powdered activated carbon. The PACT process was developed for the treatment of wastewaters from both industrial and municipal sources. In the PACT process, powdered activated carbon (PAC) is added to the active biomass in the aeration basin at a wide range of dosages to accommodate the biodegradability and adsorptive characteristics of the contaminants in the wastewater. Treatment effectiveness of this system depends on the carbon dose added, the hydraulic detention time (HDT) of the aeration basin, and the solids residence time (SRT) for the carbon-biomass mixture in the basin. The SRT affects the biological population both in terms of concentration and organism selection. SRTs can vary from 2 days to approximately 50 days.

The wastes fed into the PACT process (Figure 1) should be in an aqueous medium and have adequate nutrients to support growth of the active microorganisms in the aeration basin. The temperature range of 40 to 100°F and an influent pH range of 6 to 8 are desirable for the process. The HDT must also be sufficiently long to provide destruction of biodegradable components of the wastewater. Typically, HDTs can vary from 2 to 24 hours.

The carbon concentration is also important in determining the settling characteristics of the PAC-biomass mixed liquor and the volatilization of organics. Generally, higher concentrations of carbon will enhance the settleability of sludges removed from the basin and reduce air stripping of the organics.

Excess solids (PAC with adsorbed organics, biomass, and inert solids) are removed from the system by wasting a portion of the solids from the clarifier or thickener (Figure 1).

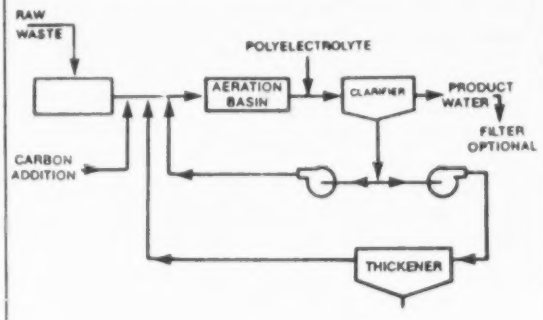

Figure 1. PACT™ process flow scheme.

The PACT system that will be used for demonstrating this technology under the SITE program will include a wet air oxidation (WAO) unit. The WAO unit will regenerate the PAC and destroy organics remaining in the biomass. This unit (Figure 2) will receive solids from the thickener and provide regenerated PAC for the aeration basin.

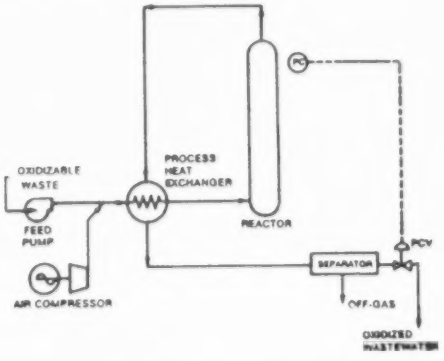

Figure 2. Wet air oxidation flow scheme.

WASTE APPLICABILITY: This technology is applicable to both municipal and industrial wastewater containing organic pollutants. It has been applied to industrial wastewater including: chemical plant wastes, coke oven flushing liquors, contaminated ground-water, dye production wastewater, food processing wastes, pharmaceutical wastes, and refinery and synthetic fuel wastes.

STATUS: The demonstration project is still in the site selection process although major portions of the demonstration plan have already been developed. The developer is ready to begin treatability studies as soon as a site is identified.

FOR FURTHER INFORMATION:

EPA Project Manager:
John F. Martin
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7758
FTS: 684-7758

Technology Contact:
William M. Copa, Ph.D.
Zimpro/Passavant, Inc.
301 West Military Road
Rothschild, Wisconsin 54474
715-359-7211; TELEX 29-0495
FAX: 715-355-3219

EPA United States
Environmental Protection
Agency

November 1988

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

Emerging Technologies Program

The Emerging Technologies Program provides the framework to encourage further testing and evaluation through pilot-scale of technologies already proven at bench-scale. Under the Emerging Technologies Program, partial funding is provided by EPA. The availability of EPA-provided resources is particularly important since some technology developers do not have the financial capabilities to independently pursue testing and evaluation of their technologies for application to hazardous waste cleanups. The instrument for funding technology developers under the Emerging Technologies Program is the competitively-awarded Cooperative Agreement. Cooperative Agreements are vehicles by which EPA can enter into jointly-funded projects with technology developers. It is extremely important to note that Cooperative Agreements require cost sharing on the part of the technology developer. The SITE Emerging Technologies Program participants are presented in alphabetical order in Table 2.

TABLE 2. SITE Emerging Technologies Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Atomic Energy of Canada Ltd. Chalk River, Ontario (EOI - 1988)	Selected Removal of Dissolved Toxic Metals by Chemical Treatment/ Ultrafiltration	Leo P. Buckley 613-584-3311	John F. Martin 513-569-7758 FTS: 684-7758	Liquid	Specific for heavy metals	X
Battelle Memorial Institute Columbus, OH (EOI - 1988)	Development of the Electro-acoustic Soil Decontamination (ESD) Process for In-Situ Applications	H.S. Muralidhara 614-424-5018	Jonathan G. Herrmann 513-569-7839 FTS: 684-7839	Solid	X	X
Bio-Recovery Systems, Inc. Las Cruces, NM (EOI - 1988)	AlgaSORB: A New Technology for Removal and Recovery of Metal Ions from Groundwaters	Dennis W. Darnall 505-646-5888	Naomi P. Barkley 513-569-7854 FTS: 684-7854	Liquid	Specific for heavy metals	NA
Colorado School of Mines Golden, CO (EOI - 1988)	Constructed Wetlands-Based Treatment of Degraded Waters for Toxic Metal Removal	Thomas Wildeman 303-273-3642	Edward R. Bates 513-569-7774 FTS: 684-7774	Liquid	Specific for heavy metals	NA
Energy and Environmental Engineering, Inc. E. Cambridge, MA (EOI - 1988)	Pilot-Scale System for the Laser Stimulated Photochemical Oxidation of Toxic Organics in Water	James H. Porter 617-666-5500	Ronald F. Lewis 513-569-7856 FTS: 684-7856	Liquid	NA	X
Envirite Field Services, Inc. Atlanta, GA (EOI - 1988)	Solvent Washing of Contaminated Soils	Thomas F. McGowan 404-876-8300	S. Jackson Hubbard 513-569-7507 FTS: 684-7507	Solid	NA	Specific for high molecular weight organics
Western Research Institute Laramie, WY (EOI - 1988)	Contained Recovery of Oily Wastes - CROW	Wesley E. Barnes 307-721-2011	Eugene F. Harris 513-569-7862 FTS: 684-7862	Solid	NA	Specific for high molecular weight organics

X = Applicable NA = Not Applicable

EPA Technology Profile
Emerging Technologies Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

ATOMIC ENERGY OF CANADA LTD.

TECHNOLOGY DESCRIPTION: The combination chemical-ultrafiltration treatment process is intended for use on toxic metals in groundwater. The process creates two streams: permeate and retentate. Permeate, the bulk of the treated water, is cleaned and released without further processing. The retentate which constitutes less than 5 percent of the feed volume, requires further attention. The retentate contains the separated heavy metal ions and can be handled in a couple of ways. It may be solidified to prevent the release of toxic metals back to the environment, or it may be recycled through the treatment process for further volume reduction. Eventually, however, the retentate must be removed for ultimate disposal.

Ultrafiltration can be applied in combination with chemical treatment to selectively remove dissolved metal ions from dilute aqueous solutions. A high molecular weight chelating agent is added to the incoming waste solution to form complexes with the metal ions to be removed. Usually, each chelating polymer has a marked selectivity for one metal cation or for a group of similar cations. The solution is then processed through an ultrafiltration membrane system that retains the macromolecular complexes (retentate), while allowing uncomplexed ions such as sodium, potassium, calcium, chloride, sulfate, nitrate, etc. to pass through with the filtered water (permeate). The filtered water can be recycled or discharged depending upon the metal removal requirements. A removal efficiency approaching 100 percent can be achieved for metal ions that have been complexed.

Since many of the simple and non-toxic ions are allowed to pass through the membrane, they are not concentrated together with the metal ions. The retentate, which may be solidified for permanent disposal, will have a smaller volume and be more resistant to leaching due to its smaller salt content and the presence of chemicals that retard migration of the toxic metals.

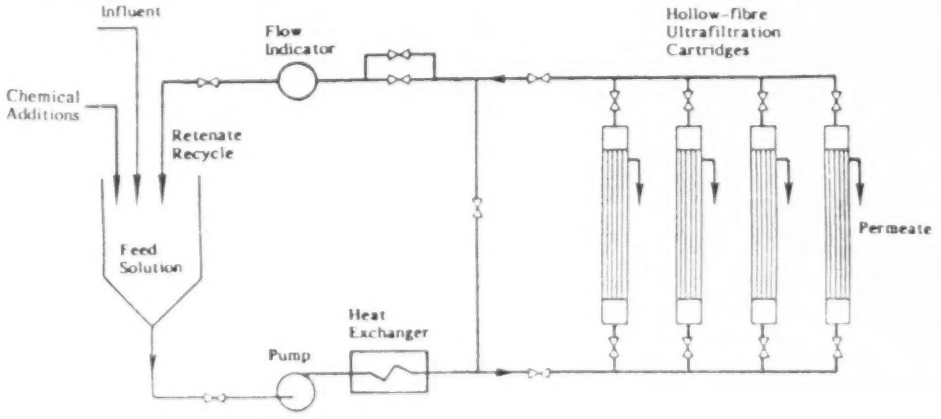

Figure 1. Mobile ultrafiltration unit.

WASTE APPLICABILITY: Even though ultrafiltration has been applied exclusively to the removal of colloidal solids and fairly large molecules, this technology may be applicable to separation of toxic heavy metal ions such as arsenic, cadmium, chromium, lead, mercury, selenium, silver and barium (as an in-situ formed precipitate) from leachates generated at Superfund sites. Other inorganic and organic materials present as suspended and colloidal solids may also be removed.

STATUS: This technology has not been applied outside of the laboratory setting. However, work on a pilot-scale mobile unit [consisting of different types of hollow-fiber ultrafiltration cartridges connected in parallel (Figure 1)] is proposed. Bench-scale experiments will be performed first to establish optimal operating conditions. These tests are expected to begin in Fall 1988, at a site in Ontario, Canada.

FOR FURTHER INFORMATION:

EPA Project Manager:
John F. Martin
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7758
FTS: 684-7758

Technology Contact:
Leo P. Buckley
Atomic Energy of Canada Ltd.
Waste Management Technology Division
Chalk River Nuclear Labs
Chalk River, Ontario KOJ 1JO
Canada
613-584-3311

EPA Technology Profile
Emerging Technologies Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

BATTELLE MEMORIAL INSTITUTE

TECHNOLOGY DESCRIPTION: The electroacoustic soil decontamination (ESD) technology is based on the application of a direct current electric field and an acoustic field to facilitate transport of liquids through soils. The components of this process consist of electrodes, an anode and a cathode, and an acoustic source. Increased transport of liquids through the soil is obtained from the synergistic effect of these two fields.

The double layer boundary theory plays an important role when an electric potential is applied to soils. For soil particles (Figure 1), the double layer consists of a fixed layer of negative ions that are firmly held to the solid phase and a diffuse layer of positive and negative ions that are more loosely held. Application of an electric potential on the double layer results in the displacement of the loosely held ions to their respective electrodes; i.e., the positively charged layer to the cathode and the negatively charged layer to the anode. The ions drag water along with them as they move toward the electrodes. After the basic mechanism of electroosmotic transport of water through wet soils under the influence of a direct current occurs, other effects (such as ion exchange, development of pH gradients, electrolysis, gas generation, oxidation and reduction, and heat generation) are produced. The heavy metals present in contaminated soils can be leached out or precipitated out of solution by electrolysis, oxidation and reduction reactions, or ionic migration. The contaminants in the soil may be cations, such as cadium, chromium, lead, and anions, such as cyanide, chromate, and dichromate. Also, the existence of these ions in their respective oxidation states depends upon the local pH and concentration gradients existing in the soil. Application of an electric field is expected to increase the leaching rate and precipitate the respective heavy metals out of solution by establishing appropriate pH and osmotic gradients.

When properly applied in conjunction with an electric field and water flow, an acoustic field

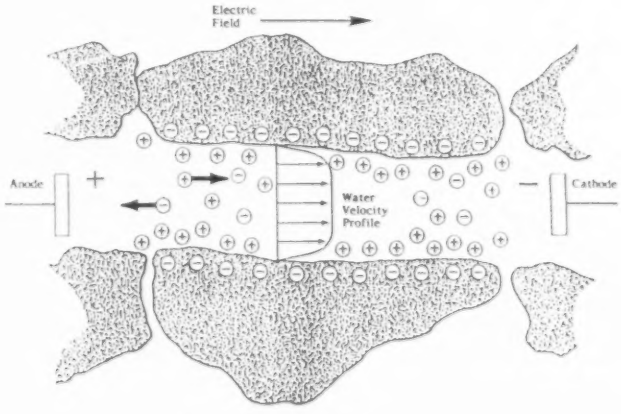

Figure 1. Electroosmosis principle.

enhances dewatering or leaching of wastes such as sludges. The phenomena that augment dewatering of wastes when using the combined technique are not fully understood. Since more contaminated particles are driven to the recovery well, the pores and interstitial spaces can become plugged. Therefore, another potential application of an acoustic field is for clearing the skin in the recovery well.

WASTE APPLICABILITY: This technology is in the evaluation stage and can be applied to the in-situ cleanup of contaminated soils. Since the technology is dependent upon surface charge, fine grained clay soils are ideal. The technology's potential for improving non-aqueous phase liquid (NAPL) contaminant recovery and heavy metal removal in-situ in clay soils could be cost effective for a site remediation if proven practical on the pilot scale.

STATUS: To date, the ESD technology has not been applied to in-situ site remediation. Further evaluation of the technology began in October 1988, in cooperation with Battelle Memorial Institute.

FOR FURTHER INFORMATION:

EPA Project Manager:
Jonathan G. Herrmann
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7839
FTS: 684-7839

Technology Contact:
H.S. Muralidhara
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201
614-424-5018

EPA Technology Profile
Emerging Technologies Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION
November 1988

BIO-RECOVERY SYSTEMS, INC.

TECHNOLOGY DESCRIPTION:
The AlgaSORB™ sorption process is designed to remove heavy metal ions from aqueous solutions and is based upon the natural, very strong affinity of the cell walls of algae for heavy metal ions. AlgaSORB™ is comprised of immobilized algal cells in a silica gel polymer. The algae are killed in the process of immobilization.

The pores of the polymer are apparently large enough to allow free diffusion of ions to the algal cells, since similar quantities of metal ions are bound by free and immobilized cells. The immobilization process serves two purposes: (1) it protects the algal cells from decomposition by other microorganisms, and (2) it produces a hard material which can be packed into chromatographic columns, which when pressurized, still exhibit good flow characteristics.

AlgaSORB™ functions as a "biological" ion-exchange resin to bind both metallic cations and metallic oxoanions (large, complex, oxygen-containing ions with a negative charge), but anions such as chlorides or sulfates are only weakly bound or not bound at all. Like ion-exchange resins, the algae-silica system can be recycled. However, in contrast to current ion-exchange technology, the components of hard water (Ca^{+2}, Mg^{+2}) or monovalent cations (Na^{+}, K^{+}) do not significantly interfere with the binding of toxic, heavy metal ions to the algae-silica matrix. As shown in Figure 1, a prototype portable effluent treatment equipment (PETE) unit, consisting of two columns operated in series, was developed. Each column contains a quarter cubic foot of AlgaSORB™. The unit is capable of treating flows of approximately one gallon per minute. Thus, AlgaSORB™, useful for removing metal ions from groundwaters or leachates that are "hard" or contain high levels of dissolved solids, can also be used to remove aluminum, cadmium, chromium, cobalt, copper, gold, iron, lead, manganese, mercury, molybdenum, nickel, platinum, silver, uranium, vanadium, and zinc.

WASTE APPLICABILITY: AlgaSORB™ will remove only heavy metal ions from aqueous solutions. Once AlgaSORB™ is saturated with metal ions, the metals are stripped from the algae using acids, bases, or other suitable reagents, thereby producing a small volume of very concentrated metal-containing solutions which must be further treated in order to detoxify them.

STATUS: Experiments to determine optimum flow rates, binding capacities of AlgaSORB™ and efficiency of stripping agents will be followed by field testing of this technology on mercury-contaminated groundwaters in the fall of 1988.

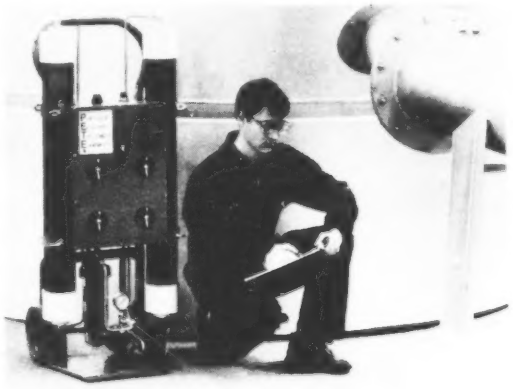

Figure 1. The PETE unit.

FOR FURTHER INFORMATION:

EPA Project Manager:
Naomi P. Barkley
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7854
FTS: 684-7854

Technology Contact:
Dennis W. Darnall
Bio-Recovery Systems, Inc.
P.O. Box 3982, UPB
Las Cruces, New Mexico 88003
505-646-5888

EPA Technology Profile
Emerging Technologies Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

COLORADO SCHOOL OF MINES

TECHNOLOGY DESCRIPTION: The constructed wetlands-based treatment technology is predicated on the concept of using natural geochemical and biological processes inherent in a man-made wetland ecosystem (Figure 1) to remove and accumulate metals from influent waters. The constructed treatment system incorporates principal ecosystem components found in wetlands, including organic soils, microbial fauna, algae, and vascular plants.

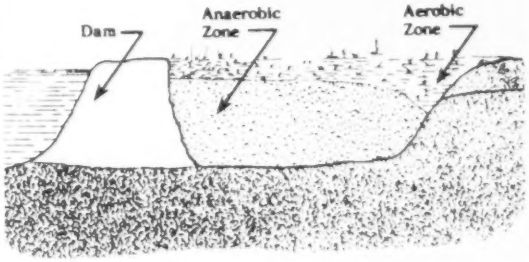

Figure 1. Typical wetland ecosystem.

In the constructed wetlands treatment system, influent waters, which contain high metal concentrations and have low pH, flow through the aerobic and anaerobic zones of the wetland ecosystem. The processes that play a role in the removal of metals by wetlands include filtration, ion exchange, adsorption, absorption accumulation by plants and microbes, and precipitation through geochemical and microbial oxidation and reduction. Metal flocculates and metals that are adsorbed onto fine sediment particles settle out in quiescent ponds, or are filtered out as the water percolates through the soil or the plant canopy. Cation exchange occurs as metals in the water come into contact with humic or other organic substances in the soil medium. Many metals are adsorbed by plants and microbes, and accumulated in their cells. These include lead, copper, nickel, molybdenum, zinc, manganese, iron and aluminum, as well as cyanide, with some retained in portions of the plant tissues after death. Oxidation/reduction reactions that occur in the aerobic/anaerobic zones, respectively, will likely play the major role in removing metals as hydroxides and sulfides.

WASTE APPLICABILITY: The wetlands-based treatment process is suitable for acid mine drainage from metal or coal mining activities. These wastes typically contain high metals concentrations and are acidic in nature. Sites identified as possible candidates for this technology include California Gulch and Clear Creek/Central City in Colorado and the New Jersey zinc mine near Minturn, Colorado. Wetlands treatment has been applied with some success on similar waste water in the eastern regions of the United States. However, the differences in geology, terrain, trace metal composition, and climate may require changes in constructed wetlands treatment for mine discharges from metal mining regions of the western United States.

STATUS: To date, a pilot plant system has been built to assess the effectiveness of constructed wetlands in treating the effluent from the Big Five Tunnel near Idaho Springs, Colorado. If successful, the results may be applicable to all constructed wetlands-based treatments, not just metal mine applications.

FOR FURTHER INFORMATION:

EPA Project Manager:
Edward R. Bates
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7774
FTS: 684-7774

Technology Contact:
Thomas Wildeman
Colorado School of Mines
Golden, Colorado 80401
303-273-3642

EPA Technology Profile
Emerging Technologies Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

ENERGY AND ENVIRONMENTAL ENGINEERING, INC.

TECHNOLOGY DESCRIPTION: This technology is designed to photochemically oxidize organic compounds in wastewater into nontoxic compounds through the application of ultraviolet radiation supplied by an Argon-Fluorine laser. The photochemical reactor is capable of essentially completely destroying very low concentrations of organic molecules. The process is envisioned as the last step in the treatment of organic contamination in groundwater drawn from a hazardous waste site or of industrial wastewater prior to discharge to the environment. In this process, the energy absorbed is sufficient to fragment the aromatic ring of an organic compound promoting the oxidation of the fragments, but the radiation is not absorbed to any significant extent by the water molecules present in the solution.

The process equipment design (10 GPM capacity) consists of a filtration unit and the photolysis reactor which could be scaled up for direct use in the field with the hardware components skid-mounted and stationed at a site (Figure 1). The exact makeup of the process will depend on the chemical composition of the groundwater being treated and, therefore, be site specific; i.e., as a pretreatment, chemical precipitation of heavy metals may be required and carbon adsorption may also be required, if the water contains high concentrations of organics.

Collected, contaminated groundwater is pumped from a feed well through a filter unit to remove suspended particles (Figure 1). The filtrate is then fed to the photochemical reactor and irradiated. Air is sprayed through the solution in the reactor to maintain the dissolved oxygen required for oxidation of the organic fragments formed by photolysis.

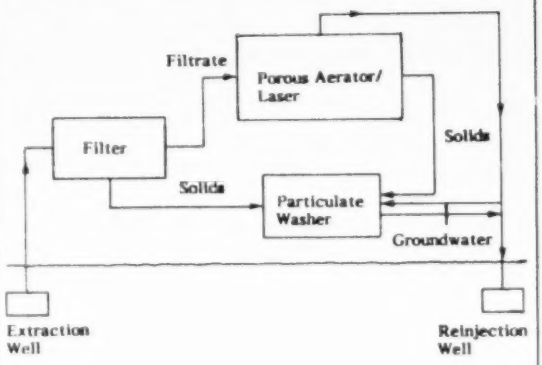

Figure 1. Diagram of the pilot scale laser-stimulated photolysis process.

The detoxified water (containing daughter products including CO_2, HCl and some volatile organics) is sent to a degassing unit where volatile materials are released to the atmosphere. Part of the detoxified groundwater is reinjected into the ground, and the rest is recycled to wash the particulate matter separated in the filtration unit. This washing procedure may be required since toxic organics in the groundwater will tend to adsorb onto the particulate matter. Washing with detoxified groundwater will cause desorption of organics from the particulate matter, reducing the equilibrium concentration on the particulate matter. The wash water is then combined with the filtrate stream and returned to the photochemical reactor for further destruction of the toxics. The cleaned particulate matter may be disposed of.

WASTE APPLICABILITY: This technology can be applied to organic contamination of groundwater drawn from a hazardous waste site

or to industrial organic-containing wastewaters, prior to discharge to the environment. This process has been demonstrated effectively in the laboratory in the destruction of single and multiple chlorinated benzenes, phenol and benzene.

STATUS: Further evaluation of this technology was initiated in October 1988.

FOR FURTHER INFORMATION:

EPA Project Manager
Ronald F. Lewis, Ph.D.
U.S. EPA
26 West Martin Luther King Drive
Risk Reduction Engineering Laboratory
Cincinnati, Ohio 45268
513-569-7856
FTS: 684-7856

Technology Contact:
James H. Porter
Energy and Environmental
Engineering, Inc.
P.O. Box 215
East Cambridge, Massachusetts 02141
617-666-5500

EPA Technology Profile
Emerging Technologies Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

ENVIRITE FIELD SERVICES, INC.

TECHNOLOGY DESCRIPTION: Solvent washing is a method of cleaning soils contaminated with heavy organic compounds, such as PCBs (polychlorinated biphenyls) and chlorodibenzodioxins (dioxins), down to very low levels. This method is based on a patented solvent blend that has successfully removed PCBs from soil down to <2 ppm, the level that allows the soil to be placed at the site without containment. The solvent used in soil washing is critical to the success of the system. It should be immiscible with water (so that the water naturally found on the soil will be displaced), and it should be able to cause the breakup of soil clods without grinding or shredding. Because of the flexibility in selecting a solvent, this technology can be tailored to remove most organic constituents from solid matrices.

Solvent washing is a simple process analogous to the dry-cleaning of clothing (Figure 1). The contaminated solid is mixed with a solvent in which the organic contaminants are soluble within a soil/solvent contactor. The mixture is agitated for an appropriate length of time (usually one hour), and then the solvent with the dissolved organic contaminant is drawn off. As is normal in a process of this type, a fraction of the solvent containing the dissolved organic contaminant remains with the solid. This is typically removed by subsequent washes until the solid is sufficiently clean to satisfy the requirements of the decontamination. The solvent from each wash goes to a reclamation system, where it is distilled, and the contaminant is concentrated as a still-bottom. The still-bottom, a small fraction of the volume of the original soil and a pumpable liquid, can be further treated off- or on-site depending on economics and other considerations. Once the desired level of decontamination is achieved, the residual solvent is removed from the soil by steam stripping. To facilitate this removal, a solvent with a high vapor pressure should be used. Aqueous discharges of this process are also limited to noncontact cooling water and the water that is initially present in the soil. The latter discharge is a very clean, low volume material, which typically does not require any additional treatment prior to discharge.

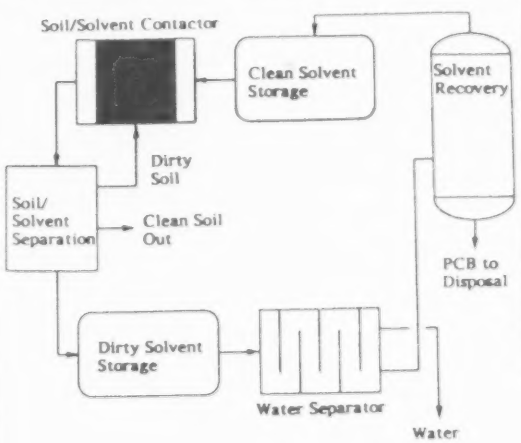

Figure 1. Simplified process schematic.

Unlike high-temperature processes such as incineration, this technology leaves the base matrix unchanged. As a result, a contaminated soil leaves this process as a clean soil suitable for sustaining vegetation. This technology can also be small enough to be "mobile", operates at low temperatures, is totally enclosed (thereby producing virtually no air emissions) and generates very few residuals.

WASTE APPLICABILITY: This technology has been shown to successfully clean metal foil, paper and sand, clay soils, high-organic soils,

and soils mixed with organic matter (i.e., leaves). It can be applied to contaminated soil laden with heavy organic compounds, especially containing PCBs and dioxins. Even though the work to date has emphasized PCBs, tests also have been conducted which show that the technology can remove chlorodibenzofurans and most types of petroleum products and oils from soil.

STATUS: Laboratory and pilot-scale programs began in October 1988.

FOR FURTHER INFORMATION:

EPA Project Manager:
S. Jackson Hubbard
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7507
FTS: 684-7507

Technology Contact:
Thomas F. McGowan
Envirite Field Services, Inc.
1447 Peachtree Street, N.E.
Suite 810
Atlanta, Georgia 30309
404-876-8300

EPA Technology Profile
Emerging Technologies Program

SITE
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

November 1988

WESTERN RESEARCH INSTITUTE

TECHNOLOGY DESCRIPTION: The Contained Recovery of Oily Wastes (CROW) process uses an enhanced oil recovery technology, presently used for secondary petroleum recovery and for primary production of heavy oil and tar sand bitumen. This technology employs the same mobile equipment as required by conventional petroleum production technology. In this process, oily wastes in contaminated soil are contained by using steam and hot water displacement to move the accumulated oily wastes and water to above ground treatment. However, even though no single conventional technology can both contain and clean up dense organic liquids at hazardous waste sites, this technology appears to remove a large portion of oily waste accumulations in situ, to stop downward migration of organic contaminants, to immobilize any residual saturation of oily wastes, and to reduce the volume, mobility and toxicity of oily wastes. It can be used to remediate shallow as well as deep contaminated areas.

After injection and production wells are drilled into the oily waste-laden soil (Figure 1), low-quality steam is injected below the deepest penetration of organic liquids and condenses, causing rising hot water to dislodge and sweep buoyant organic liquids upward into the more permeable soil regions. Hot water is injected above the impermeable soil regions to heat and mobilize the main accumulations of oily wastes, which are recovered by hot-water displacement. An oil bank is then formed because the oily wastes' displacement increases the organic liquid saturations in the subsurface pore space. Behind

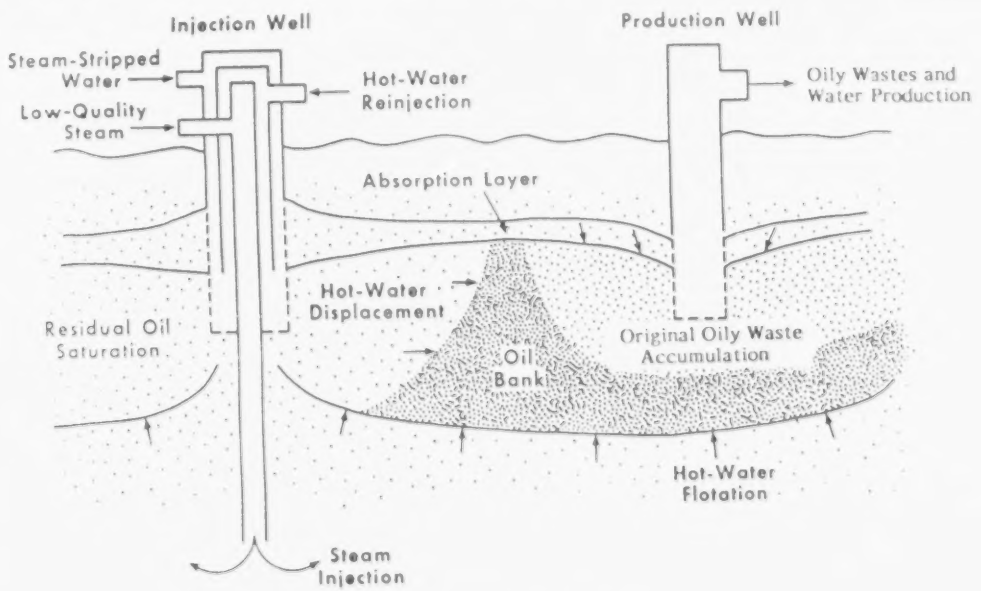

Figure 1. CROW process schematic

the oil bank, the oil saturation is reduced to an immobile residual saturation in the subsurface pore space. After the hot water injection, the oil bank is then displaced to the production well. The oil and water produced would require further treatment.

Site remediation is completed using in-situ biological treatment until groundwater contaminants are no longer detected in any water samples from the site. During these in-situ treatments, all mobilized organic liquids and water soluble contaminants are contained within the original boundaries of oily waste accumulations. The subsurface environment is protected because the hazardous materials are contained laterally by groundwater isolation and vertically by organic liquid flotation. Excess produced water is treated in compliance with discharge regulations.

WASTE APPLICABILITY: This technology could be applied to wood treating sites and other sites with soils containing dense organic liquids, such as coal tars, pentachlorophenol solutions and creosote.

STATUS: Even though this technology has not been laboratory tested, it is expected to closely resemble the previous laboratory tests in tar sand bitumen recovery using steamflood technology. Currently, this technology will be evaluated at bench and pilot scale in Laramie, Wyoming, beginning in November 1988.

FOR FURTHER INFORMATION:

EPA Project Manager:
Eugene F. Harris
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
513-569-7862
FTS: 684-7862

Technology Contact:
Wesley E. Barnes
Western Research Institute
P.O. Box 3395
University Station
Laramie, Wyoming 82071
307-721-2011

INFORMATION REQUEST FORM

The Risk Reduction Engineering Laboratory is responsible for testing and evaluation of technologies applicable to Superfund site cleanups. To be put on the mailing list to receive publications from these activities you should indicate your area of interest by checking the appropriate boxes below and mail the top half of this sheet to the following address:

Technical Information Manager
Risk Reduction Engineering Laboratory
U.S. Environmental Protection Agency
26 W. Martin Luther King Dr.
Cincinnati, Ohio 45268

(Ma 15) ☐ Superfund
(Ma 16) ☐ Superfund Innovative Technology Evaluation (SITE) Program

Name _____

Address _____

City, State, Zip Code _____

The U.S. Environmental Protection Agency plans to issue two RFPs during the coming year. A Request for Proposals will be issued in January 1989 for the Demonstration Program and a Request for Preproposals will be issued in July 1989 for the Emerging Technologies Program. To be put on the mailing list to receive these RFPs, you should indicate your area of interest by checking the appropriate boxes below and mail the bottom half of this sheet to the following address:

U.S. Environmental Protection Agency
Risk Reduction Engineering Laboratory
26 W. Martin Luther King Dr.
Cincinnati, Ohio 45268
Attention: William Frietsch, III

(004) ☐ Demonstration Program RFP
(E03) ☐ Emerging Technologies Program RFP

Name _____

Address _____

City, State, Zip Code _____